Seasonality and Distribution of Marine Birds in Saanich Inlet, Vancouver Island, B.C.

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ABSTRACT

Morgan, K.H., R. Hay and K. Vermeer. 1987. Seasonality and distribution of marine birds in Saanich Inlet, Vancouver Island, B.C. Can. Tech. Rep. Hydrogr. Ocean Sci. No. 95: iii + 53p.

Seasonal changes in species and populations of marine birds were monitored in Saanich Inlet, Vancouver Island, British Columbia from March to mid-December 1986. Highest population levels and species richness occurred during November and December, largely due to the influx of migrants. In contrast, the number of birds in July declined to less than 10% of the winter population. Shallow bays and areas with extensive intertidal habitats supported the largest and richest avifauna, whereas deep open waters and areas off rocky shorelines had far fewer species and lower densities.

The distribution and foraging activities of many birds, especially those species that fed in the exposed intertidal zone, appeared to be strongly linked to tidal cycles.

Key words: marine birds, seasonality, Saanich Inlet, SE Vancouver Island

RÉSUMÉ

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De mars à la mi-décembre 1986, on a noté les variations saisonnières des espèces et de l'abondance d'oiseaux marins fréquentant l'inlet Saanich, sur l'île de Vancouver (Colombie-Britannique). Les plus grandes richesses spécifique et abondance démographique ont été observées en novembre et décembre quand les migrateurs sont arrivés. Par contre, le nombre d'oiseaux présents à cet endroit en juillet se situait à moins de 10% de l'abondance hivernale. L'avifaune la plus abondante et la plus diversifiée fréquentait es baies peu profondes et les régions englobant d'importants habitats intertidaux. Par contre, les eaux libres profondes et les eaux au large de côtes rocheuses étaient fréquentées par moins d'espèces en nombre moins élevé.

La répartition et les activités de recherche de la nourriture d'un grand nombre d'oiseaux, surtout les espèces qui s'alimentent dans la zone intertidale exposée, semble être étroitement liées au cycle des marées.

Mots-clés: oiseaux marins, caractère saisonnier, inlet Saanich, sud-est de l'île de Vancouver

INTRODUCTION

It is well documented that marine birds in coastal waters display spatial and seasonal patterns of abundance and distribution (Manuwal et al. 1979, Stott and Olson 1982, Vermeer 1983). Spatial patterns are largely due to the variety of foraging habitats (food type and availability) produced by the complex geomorphology of coastlines. The seasonality of migration and breeding periods is likely related to cycles of prey abundance.

In aerial surveys of the marine birds of the southeast coast of Vancouver Island and adjacent Gulf Islands, Vermeer et al. (1983) observed a great diversity of bird species and densities were found to be as high as 255 birds/km. Unfortunately, Saanich Inlet, the largest fjord along the east coast of Vancouver Island, was not censused at that time. To the best of our knowledge, there have been no published reports of the distribution, abundance or seasonal occurrence of marine birds in this inlet.

The purpose of this study was therefore to characterize the populations of such birds from the mouth of Saanich Inlet to Finlayson Arm. Our objectives were to monitor the spatial and temporal patterns of distribution and abundance and to identify habitat types and geographic areas of importance to marine birds.

DESCRIPTION OF STUDY AREA

The following description of Saanich Inlet is based on the work of Herlinveaux (1962), Woods and Shaw (1981) and Juniper and Brinkhurst (1984). The inlet is a 24km-long fjord-like embayment, oriented in a north-south direction (Fig. 1). The maximum width, between Patricia Bay and Mill Bay, is 7.2km. The deepest point of the inlet (228m) occurs off Sheppard Point. A shallow sill (75m) at the mouth severely restricts deep-water circulation. Unlike the case of the "classic" fjord, there is no significant source of freshwater at the head of Saanich Inlet. Instead, most freshwater entering the inlet comes from the Cowichan River to the north. Peak discharge from the Cowichan occurs in December, while the minimum is usually in August. The fluctuations in discharge create large variations in the surface salinities at the mouth of Saanich Inlet. Water movement in the inlet is characterized by a net inflow along the Hatch Point side and a net outflow on the Moses Point side.

At Patricia Bay, the average annual precipitation is 81.5cm. Maximum precipitation occurs in December (13.7cm), while the minmum (1.8cm) takes place in July.

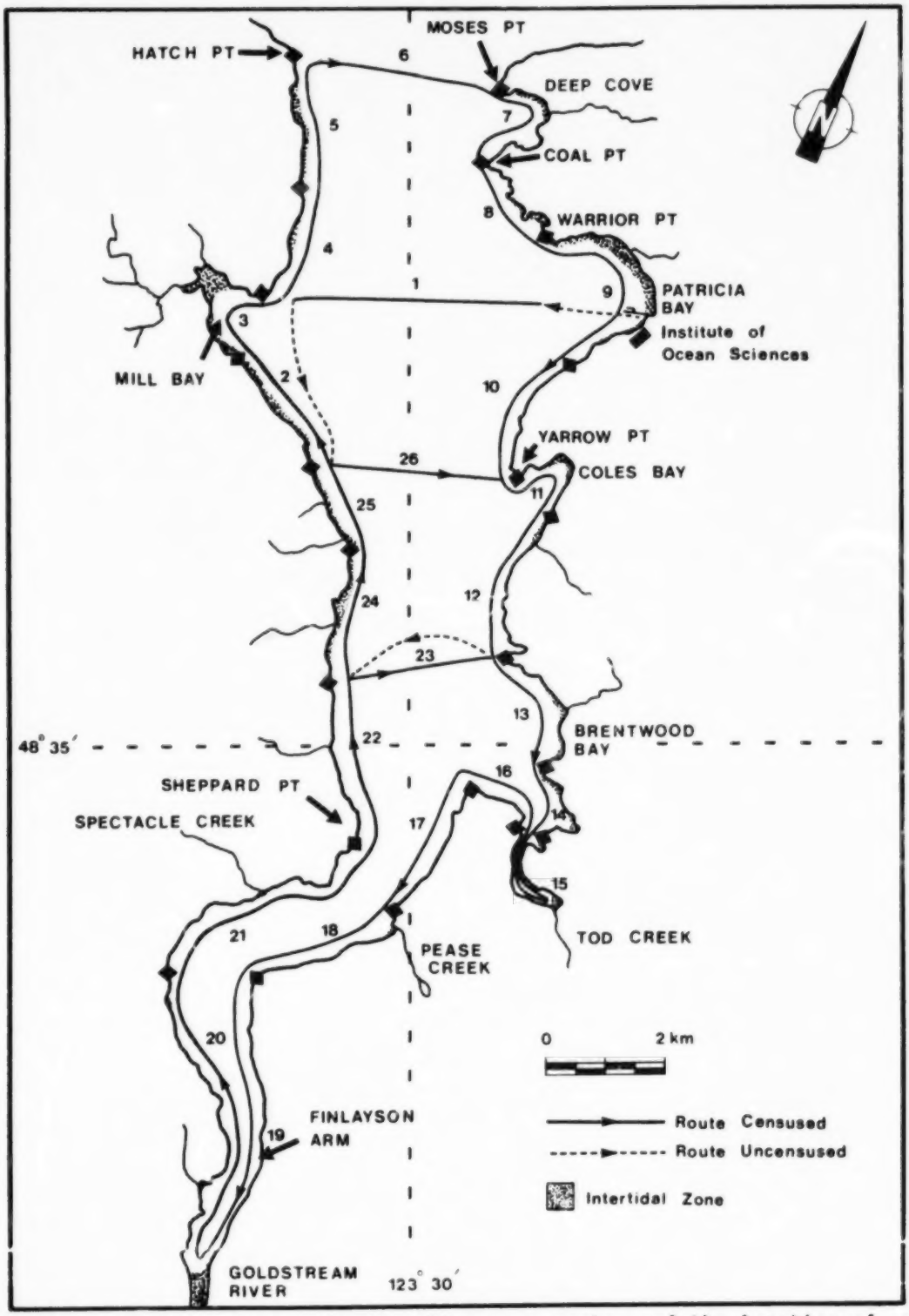


Figure 1. Saanich Inlet, showing the survey route and the location of each transect. Transect numbers are shown along the survey routes.

METHODS

Bird Censusing

Saanich Inlet: Censusing of marine birds took place at approximately 2-week intervals, from 11 March 1986 to 15 December 1986. Surveys were conducted from an 8.2m launch. As each census took between 5 and 7 hours, a wide range of tide levels occurred during each survey.

The study area was divided into twenty-two subsections (transects), according to shoreline features. In addition, four open-water transects cut across the inlet. By subdividing the inlet in this manner, we were able to accurately position the location of all birds. During each census, the launch track paralleled the coastline, approximately 150m offshore. All species of birds associated with fresh- or salt-water habitats were tallied. In addition, we made note of all birds roosting on manmade structures.

The data were tabulated both by month and by season. The following dates (modified from Manuwal et al. 1979) were used to define the seasons.
Spring: April 1 - May 15: migration of birds into and through the study area occurred.
Summer: May 16 - August 31: the population consisted primarily of summer residents, non breeders of species that nest elsewhere and a few migrants.
Fall: September 1 - October 31: the majority of southbound migrants passed through the area.
Winter: November 1 - project end: the population consisted of winter residents plus a few late southbound migrants.

Patricia Bay: The marine birds of Patricia Bay were censused from the Institute of Ocean Sciences dock, approximately every 2 weeks from 3 April 1986 to 16 December 1986. The dock extends approximately 380m into the bay, affording an uninterrupted view of the study area. By using highly visible, permanent landmarks, we divided the bay into twelve sectors (Figure 2), again to assist in positioning the location of each bird. Binoculars and a 60-power spotting scope aided in species identification.

During each census, all birds were tallied and their approximate positions were transferred to a hydrographic chart. In addition, all birds observed on shore or in flight were counted (by sector). The activity of every bird was categorized as follows: a)feeding, b)swimming/walking, c)resting or d)flying. As with Saanich Inlet, the data were tabulated by month and by season.

Habitat Analysis

Saanich Inlet: Each transect was placed into one of four general categories: a)open-water, b)shallow bays, c)rocky shorelines including steep fjord walls, or d)areas (other than bays) characterized by extensive beaches and/or intertidal zones. Very few transects followed exclusively one habitat type. However, we did feel that using the dominant type was an acceptable compromise.

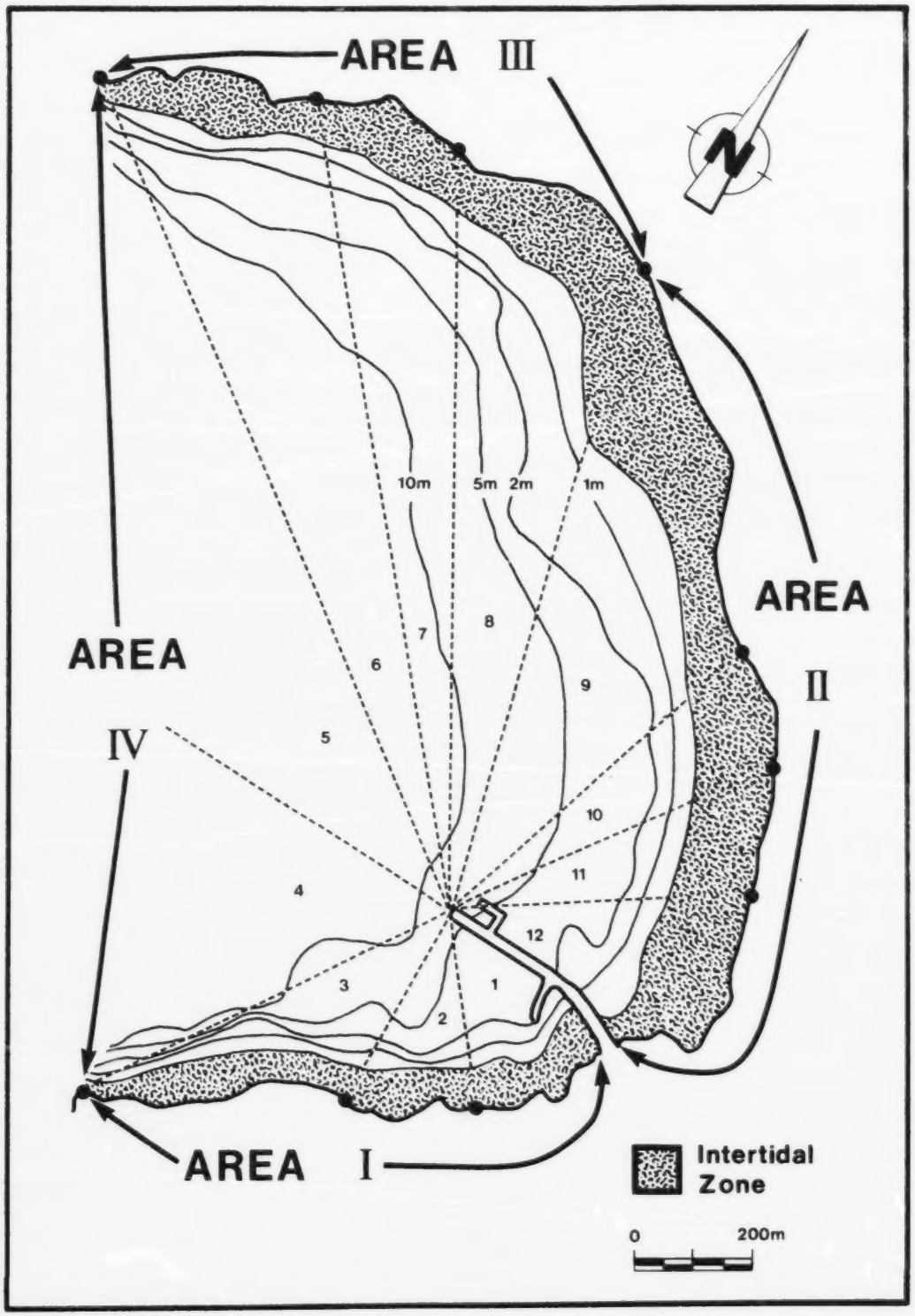


Figure 2. Patricia Bay, showing the location of each sector (1 - 12) and the 4 major habitat areas (I - IV).

Patricia Bay

Intertidal (Areas I,II,III): While it was found convenient to divide Patricia Bay into twelve sectors for the bird censusing, we recognized only four distinct areas (Fig. 2). After examining areas I, II and III at low tide, a permanent reference point was marked (in each area) on an immovable object on the shore.

The distance between zero and maximum high tides was measured in areas I,II and III. A rope, stretched between the reference point and the zero water mark, was used to position fifteen evenly spaced sampling points. The following method was repeated at each sampling point. A 6m line was centred (parallel to the water) at the sampling point. Every species of macroscopic plant and epifauna along this line was noted. Unknowns were collected and fixed with formalin. If pebbles occurred along the line, the 5 nearest the sampling point were measured. When sand was encountered, five holes (spaced at 0.5m intervals along the line) were dug to an approximate depth of 10cm. The sand was coarse-sieved (mesh width 0.5cm) and all infauna was identified or collected. All invertebrate nomenclature used in this report follows Austin (1985).

The vertical distance between successive sampling points was determined by using a sighting level and a surveying rod. After all fifteen sampling points were completed, the five most abundant animals were determined. At the midrange of each of these species, the number per unit area was determined. At the midpoint of the distribution of sand, a 300-500g sample was taken from the upper 10cm and fixed in formalin.

For each area, the total vertical "drop" in the intertidal zone was subdivided to form three subunits (upper, mid and lower intertidal).

Subtidal (Areas I,II,III): By use of SCUBA, the sampling line was extended beyond the zero tide mark to a water depth of approximately 4m. Divers followed the line noting, at 50m intervals, the plants and animals that they observed. A sand sample (top 10cm) was collected midway along each 50m interval. This sample was later fixed with formalin.

Laboratory Sample Processing

Each sand sample was kept separate. The sand was emptied into a sorting pan and all organisms larger than 1mm were removed, counted and identified. In addition, all wood and algal fragments were removed. The remaining material was dried at 200° C and sieved through 2.00mm and 0.06mm stacking sieves. The three fractions were weighed and the proportions of gravel/shell fragments, sand and mud were used to classify the substrate according to Shepard (1954).

Statistical Analysis

Saanich Inlet: Using the habitat categories (open-water, bays etc.) we determined the percent of birds present (in one habitat type) out of the total number observed throughout the inlet during each tide class. The

arcsine transformation (Zar 1974) was used on all percentage values. We regressed the transformed data against the tide level.

The total number of birds/km over the entire study period was calculated for each of the twenty-six transects. These values were subjected to a single-linkage weighted (by arithmetic mean) pair group cluster analysis using the complement of the Bray-Curtis coefficient (Romesburg 1984). This allowed us to determine which transects were most similar in bird species composition and densities.

Patricia Bay: The intertidal and subtidal communities from areas I,II and III were tested for similarities using the Jaccard Coefficient of Community (Brower and Zar 1979).

In each of the four areas, the total number of birds/km^2 (by species) was calculated. The data was subjected to a single-linkage weighted pair group cluster analysis. This enabled us to determine which areas were most similar.

For each species, the percentage of feeding birds out of the total number present was regressed against the tide level and the time of day.

For each species of bird, we attempted to determine the preferred foraging habitat by examining the proportions feeding in each of four categories: a)exposed intertidal, b)shallow water (less than 2m deep), c)mid-water depth (2-5m) and d)deep water (greater than 5m). The surface area of the four categories was estimated for each of the twelve sectors using a planimeter (Keuffel and Esser) and a hydrographic chart (no. 3441). For each sector, the number of birds by preferred foraging habitat was regressed against the surface area of the respective habitat category.

Sources of Error

Census data of marine birds seldom accurately reflect actual population levels, and consequently are an unavoidable source of error. Environmental conditions have significant effects on the numbers of birds censused because they not only affect the birds' behaviour and their observability, but also influence the observer. There is also considerable variation between observers in experience, visual acuity and ability to estimate flock size and distance (Manuwal et al. 1979).

The habitat analysis was likely another source of error. Sampling from only three locations, undoubtedly ignored substrate variability. Free swimming fauna are poorly represented in the list of intertidal and subtidal species encountered. In spite of several netting attempts, most of these organisms eluded capture. Restricting the sampling to only once (late May) during the entire study was likely a minor source of error. Nyblade (1978) observed that in intertidal areas of the Strait of Juan de Fuca with numerous species (i.e. high species richness), there was only a slight decline in the number of species over the winter. It has been observed in New Jersey (Botton 1984) and in California (Quammen 1984) that during periods of high gull and shorebird densities, the number of intertidal fauna was not significantly

reduced.

RESULTS AND DISCUSSION

Saanich Inlet

All common and Latin names of birds noted in this paper are listed in Appendix 1. In addition, bird code names (used in several tables and figures) are presented in Appendix 1.

The densities (birds per km of transect) for each species found in Saanich Inlet (averaged over the entire study period) are shown in Appendix 2. We identified 48 species of marine birds between March and December. The seasonal changes in the average number of birds, the average number of species and the average density (birds/km) are listed in Table 1. Figure 3 illustrates the variations that we observed. These changes primarily reflected the two peak migration periods and the breeding season activities. Manuwal et al. (1979) reported similar population and richness trends.

The highest population and the greatest number of species occurred in November and December, due primarily to the influx of winter residents. Total population and species richness were lowest in the summer. The July population consisted mostly of birds that breed either in or near Saanich Inlet (e.g. Pelagic and Double-crested cormorant, Pigeon Guillemot, Common Merganser, Great Blue Heron, Glaucous-winged Gull and possibly Marbled Murrelet); a few nonbreeding White-winged Scoter, Common Goldeneye and Pacific Loon also were present at this time.

The highest average density of birds in Saanich Inlet (93.7 birds/km) was far less than the 255 birds/km Vermeer (1981) observed in aerial surveys of the east coast of Vancouver Island and adjacent Gulf Islands during March. Vermeer stated that large flocks of cormorants, loons, grebes, gulls and diving ducks, had been attracted to the spawning of Pacific Herring (*Clupea harengus pallasi*) in Ganges Harbour, Saltspring Island. While in the past herring have spawned in Saanich Inlet, there presently are no spawning populations (Woods and Shaw 1981). This may account for much of the differences in observed densities.

Table 2 shows how species density and richness changed over the study period in each transect. With few exceptions, peak densities occurred during the winter. Many of the exceptions can be attributed to the occurrence of large numbers of Western Grebes. Rafts varying between 100 and 3800 birds were observed, primarily in deep water. However, a flock of approximately 2100 birds was found in Mill Bay in the early spring. Vermeer (1983) observed that this species reached the Strait of Georgia, from their interior nesting colonies, in early autumn. Its numbers rose during the winter before departing after the spawning of Herring in March.

Table 3 displays the extent of different water habitat types in Saanich Inlet. Open-water and rocky shores accounted for over 80% of the available habitat.

Table 1. Average number of birds, average number of species and average density (birds/km) in Saanich Inlet by month.

Month	No. of Birds	No. of Species	Density
March	3991	33	50.6
April	4786	33	60.7
May	1333	24	16.9
June	610	15	7.7
July	491	12	6.2
August	1000	19	12.7
September	1218	20	15.4
October	4953	27	62.8
November	5918	36	75.1
December	7386	36	93.7

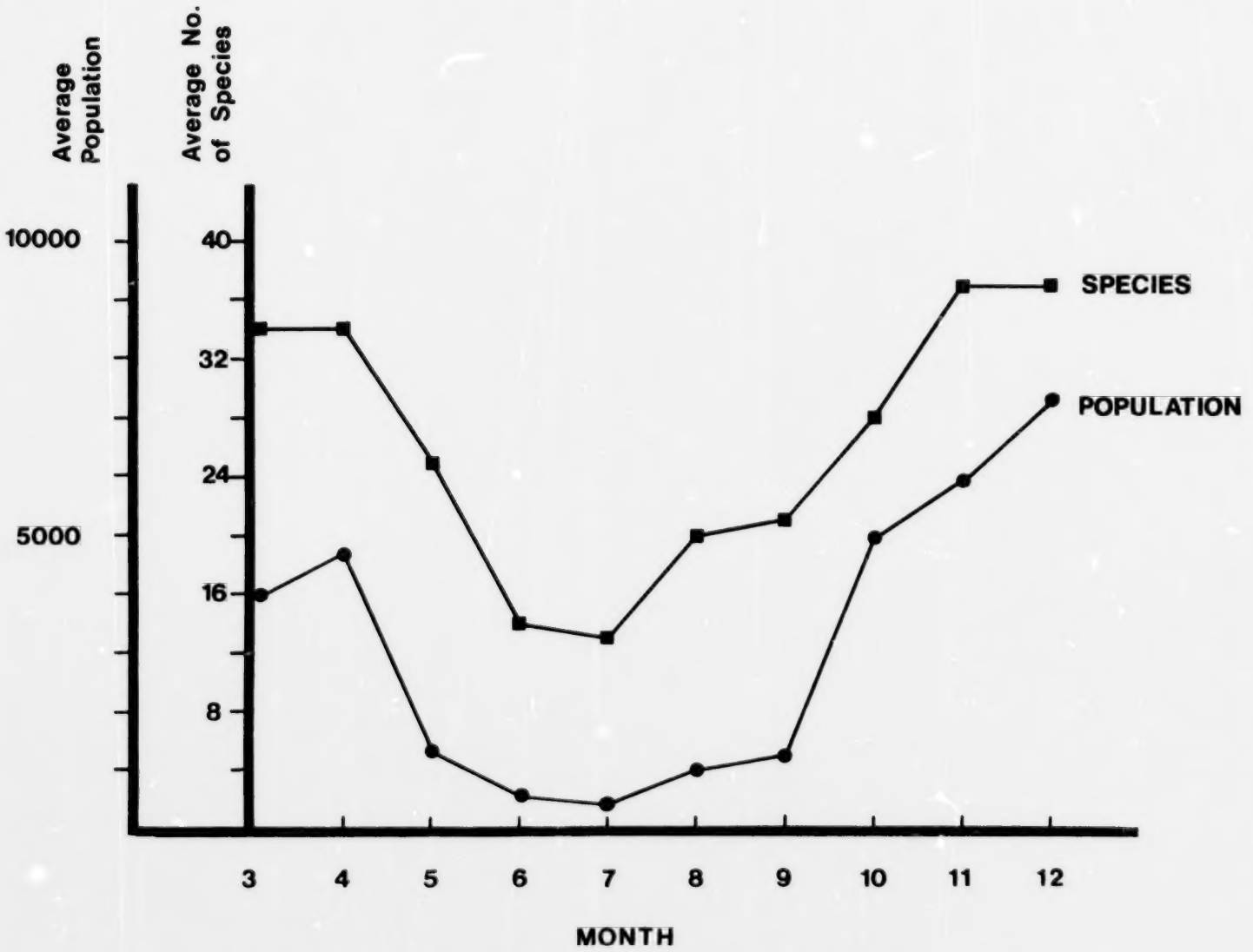


Figure 3. Average total monthly population and average number of species of marine birds observed in Saanich Inlet.

Table 2. Average density (birds/km) (D) and average number of species (R) by season in each of the 26 Saanich Inlet transects. Transect numbers are listed along the left margin. Letters in parentheses refer to habitat type.

	Spring		Summer		Fall		Winter	
	D	R	D	R	D	R	D	R
1(o)	38.5	6.0	5.0	4.0	208.5	7.5	164.6	6.6
2(i)	37.1	12.7	16.2	5.0	25.6	10.5	84.2	15.0
3(b)	404.7	15.3	20.3	6.8	69.5	11.0	374.8	19.0
4(r)	26.9	10.3	9.2	4.0	12.8	6.0	42.4	14.8
5(i)	26.2	8.3	21.6	4.4	29.8	10.3	70.9	14.4
6(o)	3.5	4.0	2.5	3.2	16.1	7.8	8.8	7.6
7(b)	64.5	16.7	16.4	6.4	40.4	12.0	77.4	17.4
8(r)	92.2	17.7	20.0	7.0	36.3	11.8	110.6	16.4
9(b)	223.6	21.7	35.4	8.8	94.6	15.3	282.5	22.0
10(r)	35.5	14.7	9.2	4.4	40.4	11.8	76.9	16.2
11(b)	82.8	13.3	8.8	3.6	22.1	7.3	68.9	11.2
12(r)	19.4	12.7	3.6	3.0	13.9	8.0	30.3	11.8
13(b)	33.6	14.3	5.5	3.8	15.5	6.8	37.4	13.6
14(b)	53.9	7.7	52.3	2.6	40.9	4.3	70.6	12.2
15(b)	72.8	10.7	14.6	3.6	25.8	6.3	81.9	10.8
16(r)	5.6	2.0	2.1	1.0	3.8	1.8	12.8	6.4
17(r)	12.0	6.3	6.0	1.4	5.5	3.0	17.0	9.8
18(r)	7.4	3.0	1.4	2.0	3.4	2.8	11.3	7.0
19(r)	22.5	11.7	10.2	4.2	6.2	5.8	73.9	15.0
20(r)	10.8	7.3	5.5	3.8	8.9	6.3	26.7	12.6
21(r)	7.5	6.7	1.5	2.2	5.2	4.5	16.6	8.0
22(r)	6.2	5.7	2.6	1.4	6.6	2.8	64.2	10.8
23(o)	2.4	2.0	1.9	1.6	2.5	3.0	10.9	4.2
24(i)	27.5	10.7	8.7	3.4	47.0	9.3	54.1	14.6
25(i)	61.5	11.0	13.5	3.4	31.7	8.8	62.4	13.8
26(o)	13.1	4.3	1.1	2.2	75.4	3.8	24.0	6.0

Habitat Type Codes: b = shallow bay
i = extensive beach/intertidal
o = open-water
r = rocky shoreline

Table 3. Extent of different water habitat types in Saanich Inlet.

Habitat Type	Area (km^2)	Percent of Total Area
Bay	7.93	12.3
Beach/Intertidal	2.77	4.3
Rocky Shoreline	11.20	17.4
Open-water	42.60	66.0

Table 4 demonstrates that shallow bays, followed by areas with extensive intertidal normally had the highest bird densities, while open-water and rocky shore habitats supported far fewer birds. Manuwal et al. (1979) and Wahl and Speich (1983) noted that the highest bird densities were usually observed in shallow bays; whereas the lowest numbers occurred in deep waters.

Species of birds that are either closely related, or exploit a resource in a similar manner, were combined into groupings (or guilds). Appendix 1 lists the guilds that each species belonged to. Figures 4a to 4j show that, with the exception of loons and sea ducks, the average number of birds present in the inlet peaked during the winter. Pacific Loons are frequently observed in very large flocks along the southern B.C. coast during spring and fall (Vermeer et al. 1983). A flock of 350 birds, present briefly during October, created the fall peak of loons. A spring peak in sea ducks has been reported elsewhere (Vermeer 1981, Vermeer et al. 1983). It was suggested by Vermeer (1981) that this peak was largely due to the influx of White-winged and Surf scoters from the United States west coast en route to their northern breeding grounds.

Table 5 lists the average number of birds/km of the 28 most common species, by habitat type. Where each species reached its highest density may suggest a preferred habitat type. The following species groupings refer to Table 5.

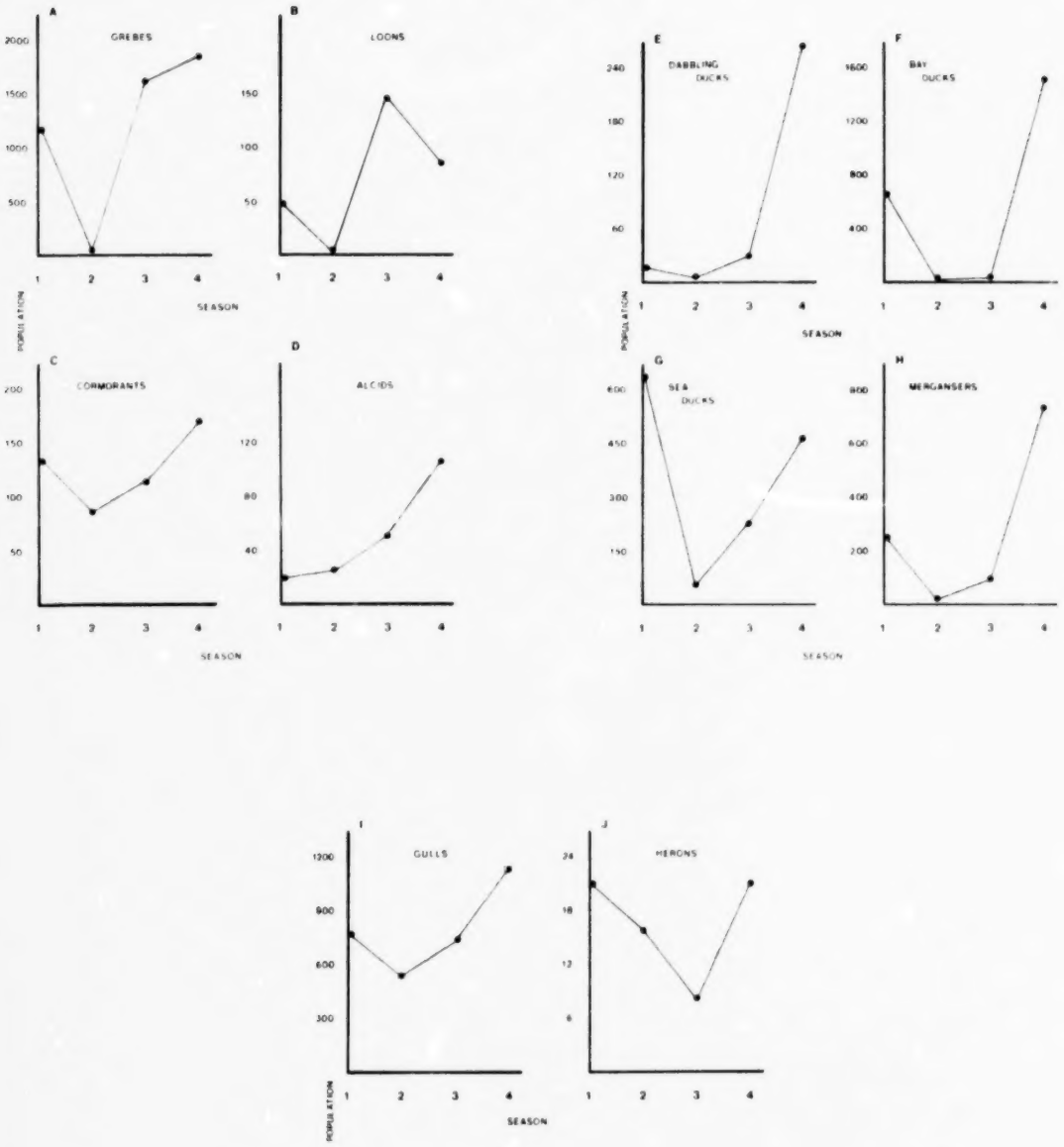
Open-water Species: Pacific Loon, Western Grebe and Common Murre were usually found in open-water habitats. According to Angell and Balcomb (1982) and Trethewey (1985), these 3 species normally feed either in open-waters (especially over reefs) or in the deep entrances of bays and estuaries. Areas with strong tidal rips are reported to be favoured by Pacific Loon and Common Murre (Manuwal et al. 1979, Angell and Balcomb 1982, Vermeer et al. 1983). However, when fishing is good these species will move into shallow waters where they capture a variety of fish including Pacific Herring, Shiner Sea Perch (*Cymatogaster aggregata*), salmon, sculpin and blennies (Phillips and Carter 1957, Angell and Balcomb 1982, Petersen 1983). They will also occasionally take crabs, shrimp, polychaetes, and gammarid amphipods

Shallow Bay Species: Common Loon, Horned Grebe and Red-necked Grebe forage for fish, crabs, shrimp and amphipods, both offshore and nearshore. However, they show a preference for sheltered bays, estuaries and entrance channels (Manuwal et al. 1979, Vermeer et al. 1983).

Double-crested and Pelagic cormorants were more abundant in shallow bays than in other habitats. Both species feed primarily upon fish and shrimp. Double-crests are reported to use shallow water estuaries and bays, especially those that have flat bottoms (Morrison et al. 1978, Manuwal et al. 1979, Ainley et al. 1981, Nysewander 1983a, Vermeer 1983). Pelagic Cormorants also utilize shallow waters, feeding in the intertidal zone (Dow 1964, Vermeer et al. 1983). However, according to Robertson (1974), Manuwal et al. (1979), Ainley et al. (1981) and Nysewander (1983a) this species usually forages in waters along rocky shores or in the surf beside steep cliffs.

Table 4. Average number of birds/survey and average b.rd density/survey in Saanich Inlet. Numbers in parentheses are standard de/iations. Data were averaged over the entire study period (n=17 surveys).

Habitat Type	Average No. Birds/Survey	Average No. Birds/km/Survey
Bay	336.5 (240.5)	73 2 (52.4)
Beach/Intertidal	143.7 (13.4)	42 6 (12.3)
Rocky Shoreline	86.6 (69.8)	21.7 (17.5)
Open-water	189.3 (245.4)	36.4 (47.2)



Figures 4a - j. Average seasonal populations of birds in Saanich Inlet by guilds (1 = spring, 2 = summer, 3 = fall, 4 = winter).

Table 5. Average densities (birds/km) for the 28 most common species of birds by habitat type. Where each species reached its highest density is indicated by *. Numbers in parentheses are standard deviations.

Species	Open	Bay	Intertidal	Rocky
Pacific Loon	1.29(2.17)*	0.31(0.39)	0.16(0.12)	0.46(0.67)
Western Grebe	35.16(46.99)*	8.65(14.69)	0.30(0.47)	0.06(0.06)
Common Murre	0.75(0.60)*	0.02(0.03)	0.02(0.03)	0.05(0.08)
Common Loon	0.11(0.11)	0.69(0.55)*	0.39(0.25)	0.16(0.14)
Horned Grebe	0.09(0.16)	4.59(3.97)*	1.66(1.46)	0.99(0.86)
Red-necked Grebe	0.12(0.07)	1.41(1.30)*	0.56(0.52)	0.35(0.28)
Double-crstd Cormorant	0.16(0.12)	1.70(0.65)*	0.77(0.47)	0.38(0.31)
Pelagic Cormorant	0.18(0.12)	1.45(0.49)*	0.44(0.33)	0.76(0.61)
Great Blue Heron	0.01(0.01)	0.55(0.39)*	0.14(0.09)	0.09(0.02)
Mallard	0.00	0.16(0.13)*	0.06(0.05)	0.05(0.04)
White-winged Scoter	0.15(0.10)	7.16(7.69)*	0.59(0.88)	0.66(0.74)
Surf Scoter	0.11(0.09)	5.81(4.54)*	1.33(1.52)	0.63(0.67)
Oldsquaw	0.04(0.08)	0.09(0.16)*	0.02(0.04)	0.04(0.06)
Common Goldeneye	0.00	2.22(3.79)*	0.97(1.67)	0.49(0.84)
Bufflehead	0.00	5.62(9.36)*	1.47(2.55)	0.55(0.96)
Common Merganser	0.00	0.40(0.31)*	0.25(0.23)	0.22(0.27)
Red-breasted Merganser	0.22(0.23)	3.61(4.37)*	1.48(1.69)	1.22(1.53)
Hooded Merganser	0.00	0.30(0.09)*	0.00	0.03(0.03)
Mew Gull	0.15(0.11)	2.29(2.54)*	1.53(0.68)	0.76(0.39)
Glaucous-winged Gull	1.04(0.09)	14.25(4.27)*	8.25(3.64)	3.82(0.98)
Pigeon Guillemot	0.03(0.02)	0.20(0.08)*	0.11(0.09)	0.08(0.05)
American Wigeon	0.03(0.05)	0.73(1.19)	0.98(0.69)*	0.21(0.34)
Barrow's Goldeneye	0.00	1.86(3.11)	2.19(3.79)*	1.10(1.88)
Bonaparte's Gull	0.41(0.31)	0.99(0.86)	1.53(1.79)*	0.54(0.57)
California Gull	0.14(0.17)	0.46(0.39)	2.73(2.47)*	0.29(0.31)
Marbled Murrelet	0.05(0.05)	0.13(0.02)	0.24(0.05)*	0.09(0.05)
Harlequin Duck	0.00	0.08(0.11)	0.02(0.04)	0.16(0.13)*
Rhinoceros Auklet	0.01(0.01)	0.01(0.01)	0.01(0.01)	0.06(0.02)*

Great Blue Herons were most frequently observed either foraging on beaches and in the shallow intertidal, or roosting on rocks and trees around shallow bays. Krebs (1974) noted that herons preyed heavily on Staghorn Sculpin (*Leptocottus armatus*), Starry Flounder (*Platichthys stellatus*), Shiner Sea Perch and Penpoint Gunnel (*Apodichthys flavidus*), species that frequently occur near eelgrass beds and pilings in estuaries and shallow bays (Eschmeyer et al. 1983).

Nine species of ducks reached their highest densities in bay habitats. In marine environments, Mallards feed primarily on plant material, notably eelgrass and various species of algae that grow in the high intertidal. They will however also take small crustaceans and molluscs and scavenge on dead salmon and salmon eggs (Bent 1962a, Angell and Balcomb 1982). These foods are often abundant along the sand and gravel shores of shallow bays and estuaries.

Shallow bays also supported the highest densities of White-winged and Surf Scoters. According to Vermeer and Bourne (1984) Surf Scoters are generally more numerous in B.C. than are White-winged Scoters. In Saanich Inlet, the reverse occurred, with White-winged Scoters being more abundant.

Numerous authors report that White-winged Scoters forage in shallow waters, feeding primarily on bivalves and gastropods and to a lesser extent on crustaceans, polychaete worms and fish (Cottam 1939, Bent 1962b, Forsell and Gould 1981, Stott and Olson 1982, Sanger 1983, Vermeer 1983, Sanger and Jones 1984, Vermeer and Bourne 1984). This species is primarily a benthic feeder, taking clams and snails either from the top or from within the substrate. While White-winged Scoters can dive to depths of at least 12m (Cottam 1939), they usually feed in water less than 5m deep. Because of their preference for benthic feeding, they are scarce along the continuous rocky shores of deep fjords (Vermeer and Bourne 1984).

Surf Scoters are reported to be most abundant along the steep rock walls of deep fjords. In such locations, they feed primarily upon Blue Mussels (*Mytilus edulis*) (Vermeer et al.1983, Vermeer and Bourne 1984). Molluscs, especially bivalves make up the bulk of their diet (Cottam 1939, Bent 1962b, Vermeer and Levings 1977, Sanger 1983). Depending on the location, and therefore on prey availability, Surf Scoters will also feed on polychaetes, barnacles, crabs, fish, sea urchins, sand dollars and starfish taken from waters usually shallower than 9m (Cottam 1939, Dow 1964, Bent 1962b, Sanger 1983).

In this study we did not find Surf Scoters to be abundant along rocky shorelines. Instead, the highest densities occurred in shallow bays. This has been observed along both Pacific (Grosz and Yocom 1972, Scott-Brown 1976, Manuwal et al. 1979) and Atlantic coastlines (Stott and Olson 1982). Stott and Olson reported that there was a decrease in density as the proportion of rocky substrate increased and in their opinion, the tendency to associate Surf Scoters with fjord walls and rocky headlands was erroneous. They claimed that the scoters must pass through these areas en route to shallow bays, their preferred foraging areas. Shallow bays and extensive intertidal zones are typically scarce or absent in most fjords. Consequently, Surf Scoters

must forage along the fjord walls. Blue Mussels are often the most abundant intertidal organism attached to these steep walls.

Oldsquaws are considered by many authors to be generalists, well distributed over all habitat types (Bent 1962b, Stott and Olson 1982, Sanger 1983, Johnson 1984). Showing no clear habitat preferences, this species will: glean food along the edge of the beach (Bent 1962b); feed on epibenthic prey in shallow water (Krasnow and Sanger 1982, Johnson 1984); or feed in open water habitats, regularly diving to depths of 20m or more (Angell and Balcomb 1982). Their diet consists of a wide range of prey including gammarid amphipods, bivalves, gastropods, isopods, copepods, polychaetes, fish and fish eggs (Cottam 1939, Krasnow and Sanger 1982, Stott and Olson 1982, Sanger 1983, Vermeer 1983, Sanger and Jones 1984). Johnson (1984) found a close relationship between the relative volume of major invertebrates in Oldsquaw stomachs and in the epibenthos, indicating that this bird species is an opportunistic feeder. Although Oldsquaw were never very abundant in the inlet, they occurred in all habitat types. However, they were most frequently observed in shallow bays.

Common Goldeneyes were also most frequently encountered in shallow bays. This species forages in a broad range of habitats: diving in waters up to 5m deep, in search of molluscs and crustaceans (Dow 1964, Angell and Balcomb 1982) or dabbling in shallow areas near shore, feeding on crabs, isopods, barnacles, gastropods, polychaetes and eelgrass seeds (Bent 1962b, Olney and Mills 1963). Stott and Olson (1982) observed, along the east coast, a preference for rocky areas over sandy beaches. Similarly, Vermeer et al. (1983) stated that Common Goldeneye were common along rocky shores, in fjords, above sand and mud substrates and in estuaries.

Another species that was most abundant in shallow bays was the Bufflehead. Erskine (1972) stated that Bufflehead prefer to forage in shallow water (usually less than 3m deep), feeding mostly during low tides. Off New Hampshire, this species used harbours and bays more readily than the coastline (Stott and Olson 1982). However, when Bufflehead were observed along the coast, they appeared to prefer rocky areas rather than sandy beaches. Vermeer et al. (1983) observed that along the B.C. coast this species occurred close to rocky shores and in sheltered bays. The diet of Bufflehead includes amphipods, shrimp, crabs, isopods, barnacles, bivalves, gastropods, polychaetes, small fish and small quantities of vegetation (Cottam 1939, Bent 1962b, Erskine 1972).

All three species of mergansers were most numerous in shallow bays. Munro and Clemens (1932) stated that Common Mergansers foraged in shallow waters, often very close to shore. Trethewey (1985) observed that this species was most abundant near the mouths of rivers. While primarily a fish eater, they will also take mussels and other molluscs, crabs, shrimp, isopods and polychaetes (Munro and Clemens 1932, Bent 1962a). We found that Common Mergansers were only slightly more abundant in bays than along rocky shores. The highest overall densities occurred (in descending order) near the mouths of Tod Creek, Goldstream River, Spectacle Creek and Pease Creek (Fig. 1). This supports Trethewey's (1985) observations that Common Mergansers were

abundant near river mouths.

Red-breasted Mergansers have been reported to be more common close to rocky shores than to sandy areas (Stott and Olson 1982, Vermeer et al. 1983). In contrast, Bent (1962a) and Brattstrom (1965) claimed that this species primarily exploits shallow bays, tidal estuaries and shallows off sandy beaches. These authors also stated that this species usually forages in water less than 1m deep, searching for fish and, rarely, crustaceans and molluscs. Our results suggested that shallow bays were the preferred foraging sites.

Hooded Mergansers were abundant only during the early winter. Vermeer et al. (1983) stated that they were most often observed near rocky shores in sheltered bays. It is suggested that throughout the year, Hooded Mergansers prefer fresh water over marine environments (Bent 1962a, Vermeer et al. 1983). Their diet consists of fish, isopods and amphipods, as well as eelgrass seeds and small amounts of algae (Bent 1962a). We encountered Hooded Mergansers most often between Deep Cove and Yarrow Point.

Mew and Glaucous-winged gulls were also most abundant in sheltered bays. Along the coast, Mew Gulls forage along beaches and mudflats, concentrating especially on kelp and eelgrass beds. They also frequently settle in shallow waters over tidal flats, dipping for edible flotsam at the edge of the beach (Angell and Balcomb 1982, Nysewander 1983b). Crustaceans and fish appear to be the most important components of their diet, although they frequently take polychaetes, gastropods, bivalves and flies (Sanger 1983).

Glaucous-winged Gulls were the most abundant gull throughout the entire study. This species forages in a wide range of habitats, although it favours shallow waters nearshore and along tide rips (Baird 1983, Vermeer 1983). We frequently observed these gulls foraging during low tides on mud flats and rocky intertidal areas. Large numbers of this species often congregated at communal roost sites. Glaucous-winged Gulls are opportunistic feeders, foraging on isopods, crabs, shrimp, barnacles, periwinkles, limpets, chitons, clams, mussels, sea urchins, starfish, polychaetes, fish, fish eggs and plants (Trapp 1979, Baird 1983, Sanger 1983).

A significant increase in the number of gulls took place in Finlayson Arm and the Goldstream estuary during the latter half of November. We observed as many as 750 gulls (85% Glaucous-winged) in less than $3km^2$. The large numbers coincided with the spawning of salmon. This sudden increase in a rich food supply attracted in unprecedented numbers not only gulls, but also Mallard, White-winged Scoter, Barrow's Goldeneye, Bufflehead, Common and Red-breasted mergansers, Common Murre and Rhinoceros Auklet.

Pigeon Guillemots were the most common alcid in shallow bays. However, they invariably occurred in the deeper waters of the bays. Krasnow and Sanger (1982) described Pigeon Guillemots as the most neritic of all the alcids, feeding almost exclusively on epibenthic prey. This species is an opportunist, feeding on shrimp, crabs, gammarid amphipods, polychaetes, bivalves and many small fish (Krasnow and Sanger 1982, Angell and Balcomb 1982, Sanger 1983). The highest concentration of Guillemots occurred between Deep Cove and Coles Bay.

Species Occurring Off Extensive Beaches: Vermeer et al. (1983) stated, that along the B.C. coast, American Wigeon concentrate near streams and estuaries. They feed on or near the surface by either dabbling in the substrate, or by tipping up in shallow water. Their diet consists almost entirely of plants, especially the seeds and roots of eelgrass, but also ulva and other species of algae (Bent 1962a, Angell and Balcomb 1982). We found Wigeon most often along extensive beaches or against the shores of sheltered bays.

Barrow's Goldeneye were more abundant off extensive beach habitats than elsewhere. According to Vermeer (1982,1983), this species is most common along rocky shores and in fjords. In contrast, Angell and Balcomb (1982) claimed that Barrow's Goldeneye prefer to feed off tidal flats and estuaries, and in protected harbours. Our results more or less agreed with both statements, as the transects with the highest densities were a beach, a bay and a rocky habitat (Appendix 2).

When found along fjord walls, Barrow's Goldeneye feed almost exclusively on Blue Mussels (Vermeer 1982, 1983). Koehl et al. (1984) observed that when Barrow's were feeding along fjord walls during high tides, they fed predominantly on mussels (with attached barnacles and periwinkles). However, at low tide, when the mussels were exposed and therefore unavailable, the goldeneye ate other bivalves, gastropods and crabs. Cottam (1939) stated that they will also eat amphipods, isopods, polychaetes, starfish, sea urchins and fish. Koehl et al. (1984) believed that Barrow's Goldeneye minimize their diving effort by feeding on prey that are available at a given tide level. We suggest that by being a generalist, (rather than specializing only on mussels), Barrow's Goldeneye can exploit a wide range of prey in a variety of habitats.

Bonaparte's and California gulls were far more abundant along those transects with extensive beaches than along any others. Bent (1963) described the Bonaparte's Gull as largely insectivorous, feeding over rafts of drifting seaweed. By plunging headfirst into the water or by probing the edges of beaches for edible flotsam, they capture shrimp, gammarid amphipods and small fish (Bent 1963, Angell and Balcomb 1982, Sanger 1983, Vermeer et al. 1987). California Gulls are opportunistic feeders, scavenging beaches and the exposed intertidal for a variety of organisms including crabs, amphipods, isopods and molluscs. They also feed on small surface swimming fish (Bent 1963). According to Manuwal et al. (1979) extensive gravel and sand beaches are important roost sites at low tides for several gull species, including Bonaparte's and California. We suggest that it was the presence of roost sites that attracted these species to areas with extensive foreshores.

Marbled Murrelets were also more abundant in waters off areas with extensive foreshores. This species is reported to prefer foraging away from shore, off entrance channels, rocky shores and over reefs (Angell and Balcomb 1982, Krasnow and Sanger 1983). The literature suggests that Marbled Murrelet feed throughout the entire water column, capturing small schooling fish, mysids, euphausiids and gammarid amphipods (Angell and Balcomb 1982, Sanger 1983). Manuwal et al. (1979) reported that this species often forages in tidal convergences. Typical of most of the areas with extensive beaches was a

steep dropoff below the intertidal zone. We suggest that this feature may at times create increased turbulence or upwelling. Such an enriched environment would likely support greater numbers of prey.

Rocky Shore Species: Harlequin Ducks are opportunistic feeders, often foraging in shallow, turbulent waters along rocky shores (Bent 1962b, Manuwal et al., Dzinbal and Jarvis 1984). Their diet includes crabs, gammarid amphipods, limpets, chitons, mussels, and occasionally fish and eelgrass (Cottam 1939, Bent 1962b, Dzinbal and Jarvis 1984). In Saanich Inlet, Harlequins were only slightly more abundant along rocky shores. Never numerous, they were observed in only 8 transects. The area between Coal Point and Warrior Point, which features many small islets and rocky points consistently had the highest number of Harlequins.

Rhinoceros Auklet was another species that was more abundant along rocky shores. Angell and Balcomb (1982) reported that in coastal waters this species feeds in estuaries and in entrance channels especially over reefs diving for a variety of fish including Pacific Herring and Pacific Sand Lance (*Ammodytes hexapterus*). In this study, Rhinoceros Auklets were often observed along the rock walls of Finlayson Arm. They also occasionally occurred at the mouth of the inlet east of Hatch Point. These locations fit the description by Angell and Balcomb of preferred foraging habitats. This species was never abundant in Saanich Inlet. Between March and mid-November, we observed on average 1 Rhinoceros Auklet per month. However, from mid-November until the end of the study, there were as many as 13 auklets present. The increase, mostly in Finlayson Arm, was likely related to the salmon spawning in Goldstream River.

Influence Of Tide Level On Bird Distribution

The proportion of birds within each habitat type during a given tidal interval (out of the total number present in the entire inlet), were regressed against the mid-point of each interval (Table 6). The proportion of birds present off beach habitats and off rocky shores showed no significant association with the tide level. In contrast, the bird populations in bays and in open-waters appeared to be strongly correlated with tidal level. As the level rose, bays supported a decreasing percentage of birds (Fig. 5a). We interpret this to indicate that during low water, there were greater opportunities for feeding, loafing or roosting. We also suggest that the increase in the proportion of birds in open-water habitats as the tide rose (Fig. 5b) was largely a result of birds leaving the bays.

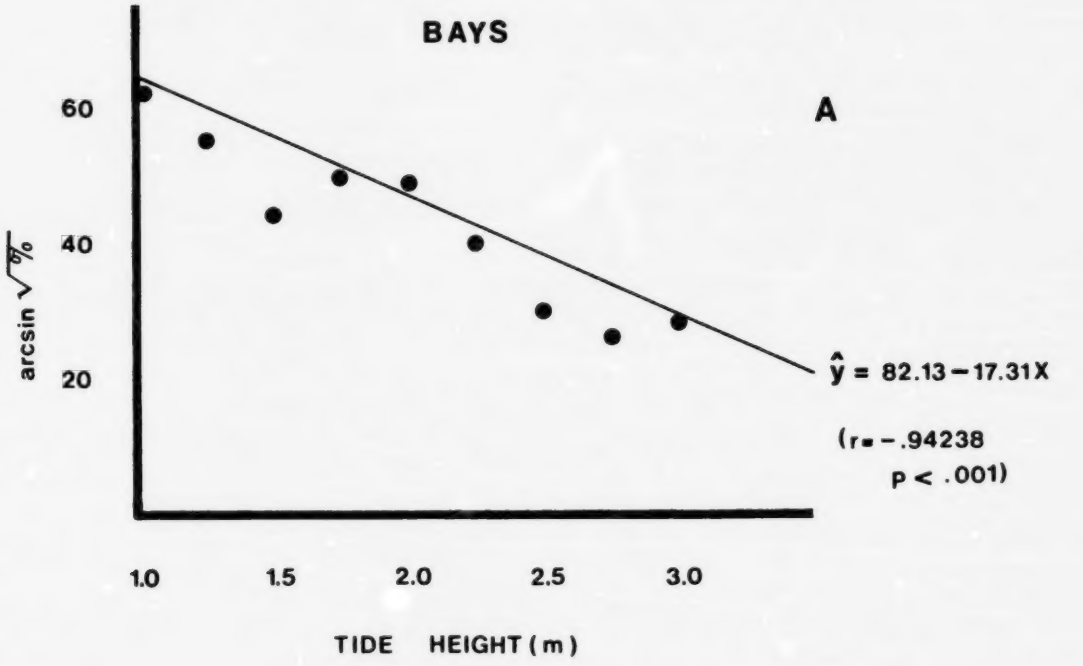
Transect Density Similarities

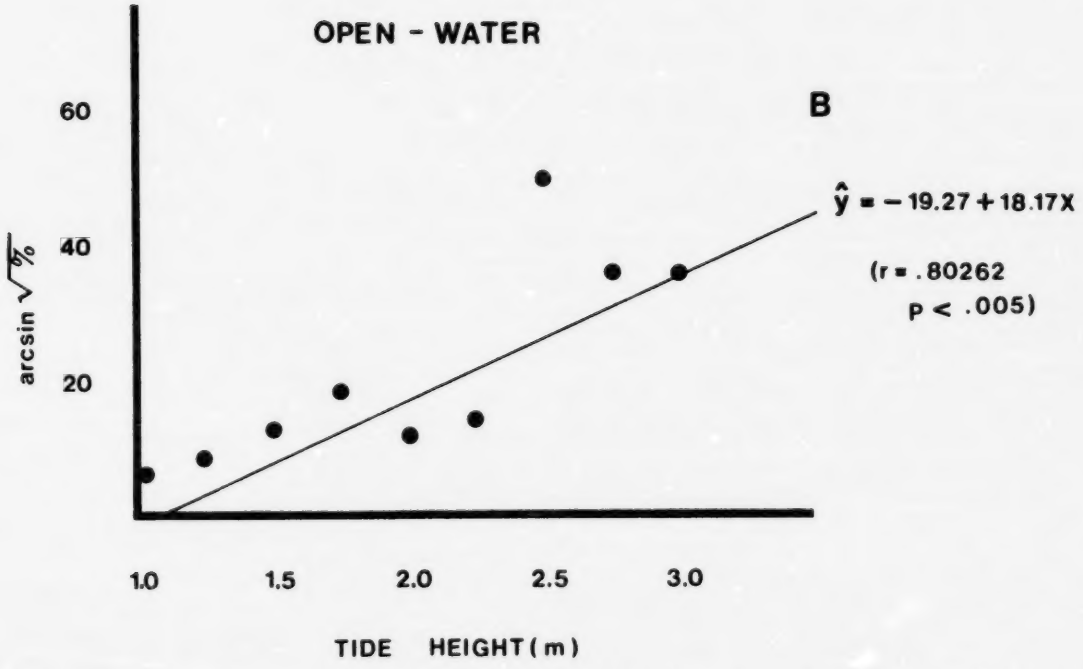
Figure 6 displays the results of the cluster analysis of the bird species densities in each transect. Out of thirteen pair combinations, nine were of the same habitat type. Apparently, like habitats were exploited by similar bird species in similar densities. In several cases, the clustering occurred either between adjacent transects or between transects on opposite sides of the inlet, regardless of habitat type. This suggested several

Table 6. Number of birds observed within each habitat type by tide interval. The proportion within each habitat type were regressed against the mid-point of each tide interval. Regression analysis results are presented beneath each habitat type.

	Habitat Type				
Tide Interval (meters above zero water level)	Beach	Rocky	Bay	Open	Total
1.00-1.25	316	877	4883	79	6155
1.26-1.50	202	310	1187	39	1738
1.51-1.75	216	342	593	60	1211
1.76-2.00	772	1322	4095	682	6871
2.01-2.25	44	907	1308	94	2353
2.26-2.50	751	905	1339	172	3167
2.51-2.75	715	754	2519	5901	9889
2.76-3.00	1814	1222	1361	2399	6796
3.01-3.25	1142	3456	3005	4820	12423
	r=.3493	r=.0895	r=-.9420	r=.8026	
	ns	ns	p<.001	p<.005	

ns = non-significant





Figures 5a and 5b. Percentage of birds (of total Saanich Inlet population) present in bays and open-water habitats relative to tide height. Regression analysis results are also presented.

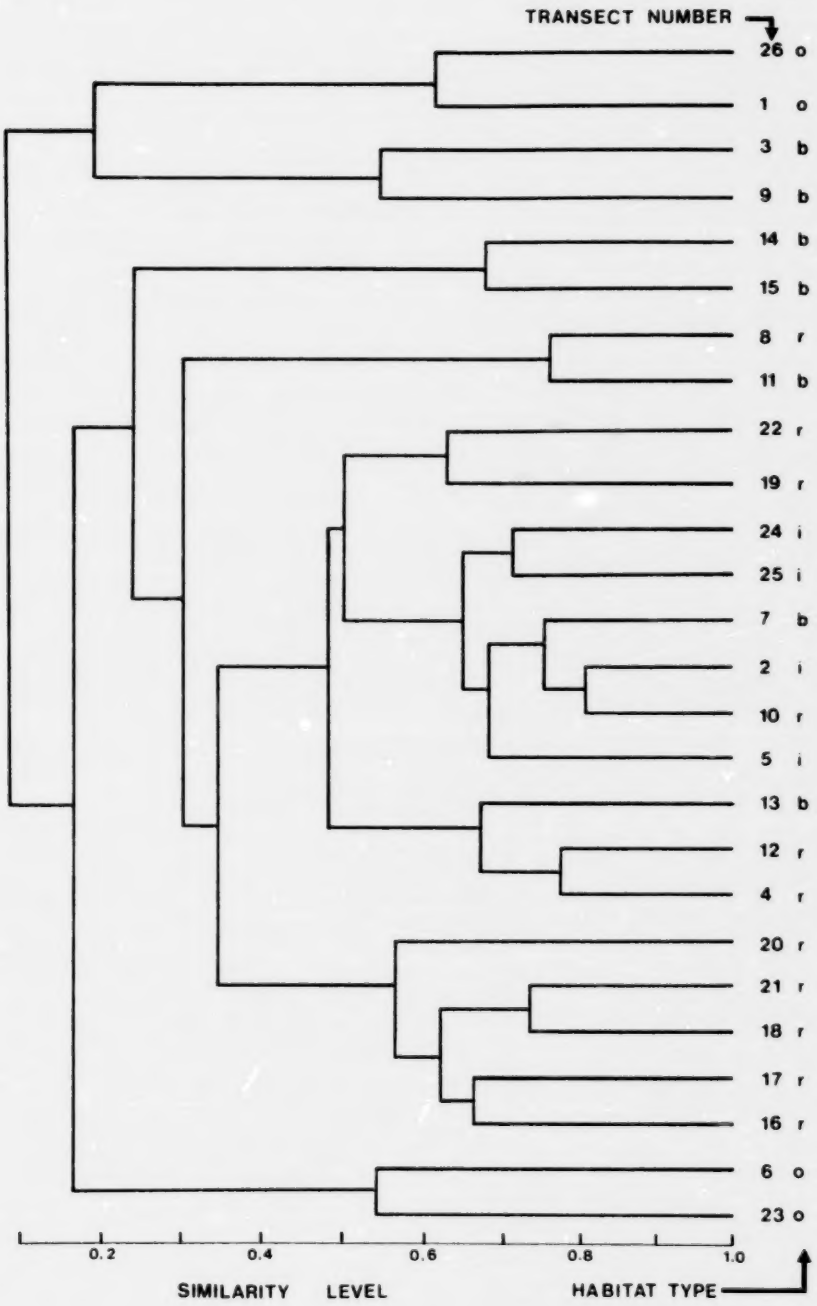


Figure 6. Dendrogram of the cluster analysis of species densities in each of the 26 transects. A high similarity level indicates a greater number of shared species and similar population densities. See Table 2 for habitat-type codes.

possibilities: 1)some transects had been incorrectly labelled, 2) the actual habitat differences between some transects were only minor and had little impact on the birds, and 3) many species of marine birds have wide habitat tolerances, allowing them to exploit a variety of situations. We believe that each of these suggestions is partially correct.

Patricia Bay

Appendix 3 lists all of the species identified from the habitat sampling, as well as providing a brief description of areas I,II and III.

Table 7 (summary of Appendix 3) shows that area I had the highest species richness. Nyblade (1978) observed that in the Strait of Juan de Fuca species richness was highest in the rocky intertidal, while exposed sand and gravel areas had the fewest species. Our results were similar. By using the Jaccard Coefficient of Community Similarity, we calculated how the intertidal and subtidal communities differed between the three areas. This coefficient ranges from 0 (no species common to both communities) to 1.0 (all species common to both communities) (Brower and Zar 1979). The values listed in Table 8 show that while areas II and III were most similar, the degree of overlap (ie. shared species) was quite low. This suggests that, at least on the basis of species presence/absence, the three areas were fairly distinct.

Figure 7 illustrates the monthly changes in the average number of birds and the average number of species in Patricia Bay. The relationships followed closely those observed in Saanich Inlet (Fig. 3).

Table 9 lists the bird species densities observed in each area during the entire study period. Area II supported the greatest number of species (34) and more species reached their maximum density there than in the other areas. While the second highest species richness occurred in area III, only two species reached their peak density there. As would be expected for a deep water habitat, area IV had the lowest species richness.

Foraging habitat is likely to be more crucial to a species of bird than is (for example) a roost site. Table 10 shows the feeding densities in each sector of the 20 most common bird species. Area I appeared to be the most frequently used foraging location of Common Loon, Horned Grebe, Pelagic Cormorant, Barrow's Goldeneye and Bufflehead. All but Pelagic Cormorants foraged in the shallower waters of this area, Pelagics foraged more often in slightly deeper waters.

Double-crested Cormorant, White-winged Scoter, Surf Scoter, Common Goldeneye and Marbled Murrelet foraged most heavily in the shallow waters of area II, close to shore. Great Blue Heron, Glaucous-winged Gull and Mew Gull also foraged more in area II, hunting either in the exposed intertidal or in the extreme shallows at the water's edge. Mallards and American Wigeon usually fed during low tide, on the extensive beds of eelgrass and algae (especially Ulva sp. and Enteromorpha sp.) as well as along the water's edge.

Western Grebe, Red-necked Grebe and Red-breasted Merganser foraged more

Table 7. Summary of Appendix 3, listing the number of intertidal and subtidal species found in Patricia Bay by area. Also listed are the average densities of the most common intertidal organisms and the average number of molluscs found in the subtidal sediment samples.

	Area		
	I	II	III
Number of species of:			
Plants	16	8	11
Annelida	18	16	9
Crustacea	40	30	22
Mollusca	32	25	23
Echinodermata	10	3	6
others	14	8	8
Total	130	90	79
Intertidal			
Average density ($no./m^2$)			
Barnacles	34000	16000*	38000
Periwinkles	8500	2000*	5500
Mussels	400	2400*	500
Limpets	400	1300*	1900
Subtidal Molluscs			
Average density/ kg of sediment (dry weight)			
Gastropods	15	25	17
Bivalves	30	60	35

* note: these densities apply to rock surfaces only. As there were very few rocks in area II, the overall density of these organisms was extremely low.

Table 8. Similarities between the intertidal and subtidal communities of areas I,II and III (Patricia Bay) using the Jaccard Coefficient.

	Area I-Area II	Area I-Area III	Area II-Area III
Jaccard Coefficient	.3949	.4247	.4444

$$\text{Jaccard Coefficient} = \frac{C}{S1+S2-C}$$

where: C is the number of species common to both communities and S1 and S2 are the total number of species in communities 1 and 2 respectively

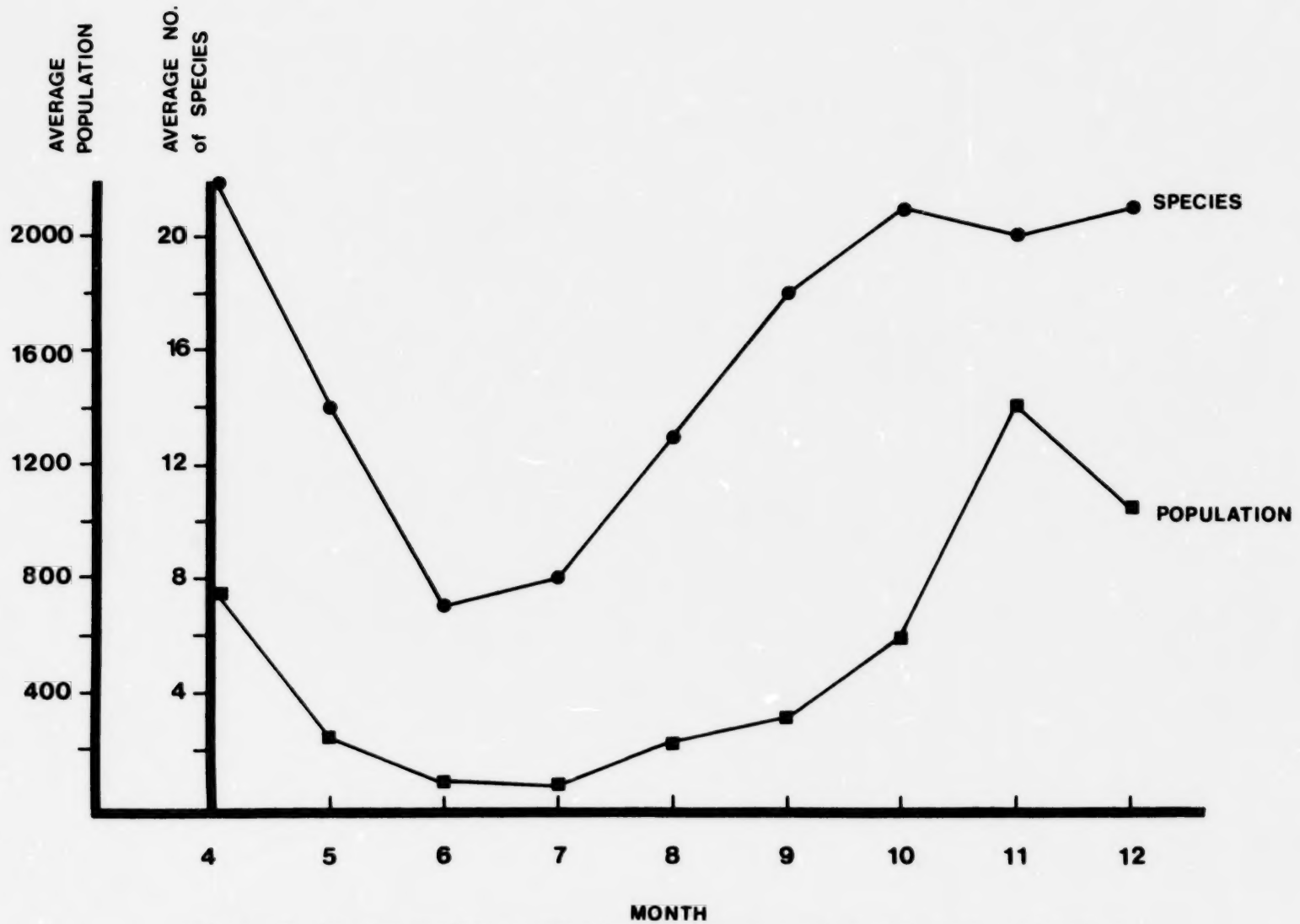


Figure 7. Average monthly population and average number of species of marine birds observed in Patricia Bay.

Table 9. Species densities (birds/km^2) for each area of Patricia Bay (entire study period). The area in which a species reached its maximum density is indicated by *.

Species	Area I	II	III	IV
Common Loon	151.63*	98.16	74.98	50.12
Pacific Loon	12.13	6.69	17.41	36.85*
Red-throated Loon	0.00	2.23*	0.00	0.00
Western Grebe	0.00	22.31	44.19*	4.42
Red-necked Grebe	181.95	149.48	239.68*	128.24
Horned Grebe	934.01*	760.77	740.47	63.38
Eared Grebe	30.33*	11.16	2.68	0.00
Pied-billed Grebe	0.00	2.23*	1.34	0.00
Double-crested Cormorant	103.11	116.01	60.26	364.08*
Pelagic Cormorant	54.59	24.54	24.10	100.23*
Brandt's Cormorant	0.00	2.23*	0.00	0.00
Great Blue Heron	48.52*	42.39	8.03	2.95
Canada Goose	42.46*	2.23	0.00	0.00
Mallard	30.33	127.17*	37.49	0.00
Green-winged Teal	0.00	8.92*	0.00	0.00
Blue-winged Teal	0.00	20.08*	0.00	0.00
American Wigeon	236.54	310.11*	258.43	5.89
Northern Pintail	0.00	11.16*	0.00	0.00
Greater Scaup	0.00	249.87*	29.46	0.00
Black Scoter	0.00	22.31*	1.34	0.00
White-winged Scoter	278.99	1885.19*	283.87	17.69
Surf Scoter	163.76	785.31*	376.26	224.05
Oldsquaw	18.19*	0.00	8.03	2.95
Barrow's Goldeneye	260.79*	66.93	53.56	0.00
Common Goldeneye	242.60*	187.40	133.90	20.48
Bufflehead	412.42	588.98*	295.92	2.95
Common Merganser	54.59*	0.00	5.36	0.00
Red-breasted Merganser	248.67	294.49	435.18	496.74*
Hooded Merganser	24.26	37.93*	4.02	0.00
Bonaparte's Gull	30.33	44.62*	44.19	7.37
Mew Gull	60.65	374.81*	89.71	23.58
California Gull	0.00	33.47*	5.36	0.00
Thayer's Gull	0.00	0.00	1.34*	0.00
Western Gull	0.00	2.23*	0.00	0.00
Glaucous-winged Gull	648.96	992.79*	263.78	69.28
Common Tern	0.00	0.00	0.00	26.53*
Common Murre	0.00	0.00	2.68	14.74*
Pigeon Guillemot	12.13	11.16	16.07	20.64*
Marbled Murrelet	12.13*	11.16	4.02	1.47
Total species observed	25	34	31	23

Table 10. Average feeding densities (birds/km^2) for the twenty most common species of birds in Patricia Bay. Densities were averaged over the entire study period. See Appendix 1 for species codes.

	Area I			Area IV		Area III			Area II		
	1	2	3	4	5	6	7	8	9	10	11	12
COLO	161	165	89	39	25	37	64	51	50	105	63	142
PALO	0	0	13	19	51	6	5	4	4	15	0	0
WEGR	0	0	0	0	3	46	16	0	25	35	16	0
RNGR	121	275	114	105	42	31	354	166	71	15	78	142
HOGR	484	1651	380	62	11	176	370	1093	454	690	516	568
DCCO	60	55	51	4	65	9	32	38	21	105	63	90
PECO	40	0	76	19	3	3	21	17	4	15	0	26
GBHE	40	0	38	0	0	0	5	13	21	30	0	116
MADU	60	0	13	0	0	37	0	0	0	255	375	361
AMWI	121	138	63	0	0	243	370	0	121	0	0	516
WWSC	101	578	190	19	3	243	32	234	937	150	735	1627
SUSC	161	110	114	47	181	299	171	145	287	90	954	736
BAGO	81	303	228	0	0	37	32	47	42	0	63	52
COGO	20	110	114	0	0	117	48	85	54	15	31	232
BUFF	383	826	114	8	0	182	279	315	396	705	360	736
RBME	81	83	317	97	169	330	0	315	316	135	109	155
MEGU	20	0	0	8	0	3	0	17	162	120	172	39
GWGU	242	413	203	0	3	31	59	102	192	180	438	387
PIGU	0	0	12	27	8	14	5	4	10	0	0	0
MAMU	0	0	25	0	0	3	0	4	12	30	0	0

frequently in area III. Red-necked Grebe and Red-breasted Merganser were most often observed diving very close to shore, whereas Western Grebe generally hunted in the deepest waters of this area.

Only 2 species (Pacific Loon and Pigeon Guillemot) foraged primarily in area IV. While several authors state that Pigeon Guillemots forage in shallow waters of bays and along beaches (Angell and Balcomb 1982, Sanger 1983, Vermeer 1983), this was not the case in Patricia Bay.

Figure 8 shows the results of the cluster analysis of the bird species densities from the 4 areas. Areas I and III, which appeared quite similar physically (ie. rocky shorelines), shared the highest number of species (75% overlap). As mentioned earlier, areas I and II had more intertidal fauna in common. The analysis therefore suggests that the birds may have been responding more to broad habitat features, than to variations in the abundance of intertidal prey. As expected, area IV had fewer bird species in common with the other 3 areas (35% overlap).

Table 11 lists the results of the regression analyses between the proportion of birds feeding and tide height, and time of day. Seven species showed significant negative associations between the proportion feeding and the tide height. Birds that forage in the exposed intertidal and in shallow waters at the edge of the beach (Great Blue Heron, Mallard, American Wigeon, Mew Gull and Glaucous-winged Gull) were most negatively correlated with tide level. White-winged Scoter and Barrow's Goldeneye also fed less with increasing tide height. These negative correlations may have been related to a greater availability of benthic prey at low tide. Nyblade (1978) noted that the richness and diversity of invertebrates increased with decreasing tide height. Common Goldeneye was the only species that showed a significant positive association with increasing tide height. This species feeds heavily on crab, shrimp and amphipods (Cottam 1939, Olney and Mills 1963). Such prey may either be more active (and therefore more easily detected) on flooding tides, or they may be more abundant in the upper intertidal.

For three species of birds, the proportion feeding decreased significantly with the time of day. Energy requirements are at their highest in the morning, possibly explaining why many species feed more heavily at this time. Double-crested Cormorant was the only species that showed a significant positive correlation with time of day. We can offer no explanation for this result.

Although the feeding proportions of Surf Scoters and White-winged Scoters followed very similar patterns with the time of day, they did peak at different time intervals during the afternoon (Figure 9a). This may demonstrate a way of reducing food competition between two closely-related species.

Figures 9b and 9c show the percentage of Mallard and American Wigeon feeding versus the time of day. Bent (1962a) stated that Wigeon feed mostly in the early morning and again in the late afternoon. Figure 9b suggests that Mallard were also more active feeders in the early and late hours of the day.

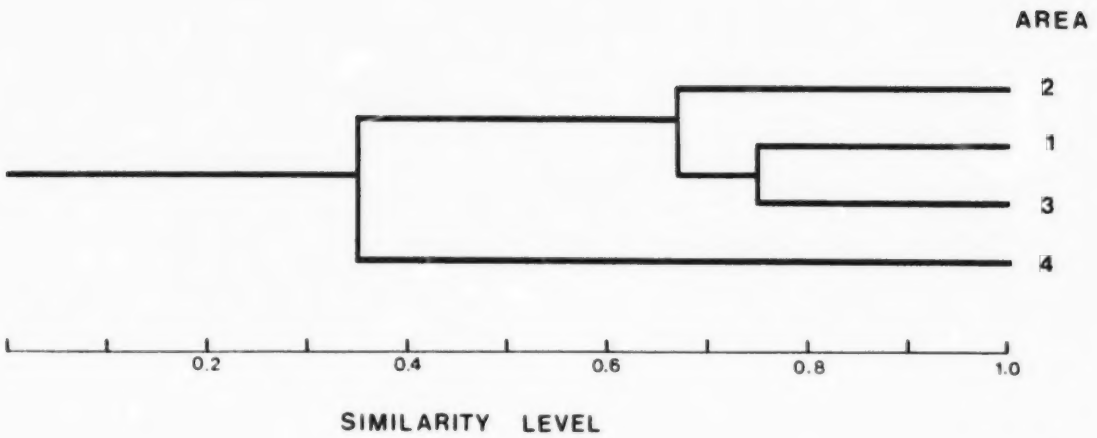


Figure 8. Dendrogram of cluster analysis of population densities in the 4 major areas of Patricia Bay.

Table 11. Results of regression analyses between the percent of birds feeding (arcsine transformed) and the tide height and the time of day. Only the densities of the twenty most common species were analyzed. See Appendix 1 for species codes. Numbers in parentheses are the number of tide or time intervals used in the analysis.

	Tide		Time of Day	
	r	significance	r	significance
Species				
COLO	-.4248(11)	ns	-.4320(8)	ns
PALO	*		-.4432(6)	ns
WEGR	+.5341(6)	ns	*	
RNGR	-.2905(10)	ns	-.5829(8)	ns
HOGR	-.3051(11)	ns	-.2926(9)	ns
DCCO	-.3953(11)	ns	+.8463(7)	p<.005
PECO	-.2208(11)	ns	+.1066(8)	ns
GBHE	-.9262(6)	p<.005	-.4644(7)	ns
MADU	-.9512(6)	p<.0025	-.6165(9)	ns
AMWI	-.8567(6)	p<.025	-.3416(5)	ns
WWSC	-.6894(9)	p<.025	-.0471(8)	ns
SUSC	-.5816(8)	ns	+.3900(8)	ns
BAGO	-.8008(8)	p<.01	-.3410(7)	ns
COGO	+.7443(10)	p<.01	-.2631(8)	ns
BUFF	-.0096(9)	ns	-.7429(8)	p<.025
RBME	-.4956(8)	ns	+.7067(7)	ns
MEGU	-.8571(11)	p<.0005	-.7151(9)	p<.025
GWGU	-.8447(11)	p<.001	-.9012(9)	p<.001
PIGU	-.3977(9)	ns	-.1541(8)	ns
MAMU	-.2043(8)	ns	*	

* = insufficient intervals for analysis
ns = non-significant

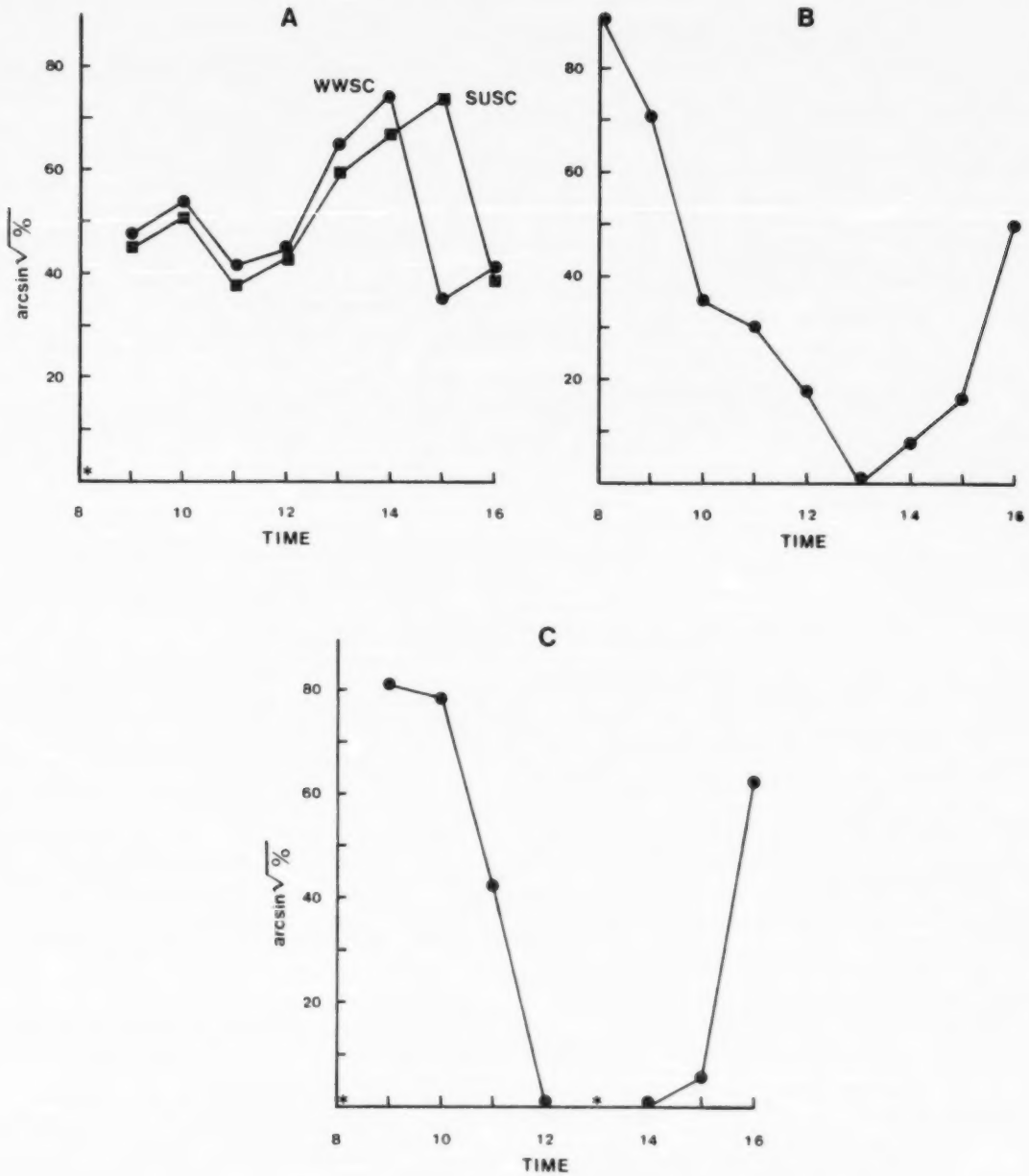


Figure 9a - c. Relationship between time of day and the percentage of birds feeding. 9a = White-winged Scoter (WWSC) and Surf Scoter (SUSC), 9b = Mallard, 9c = American Wigeon. Species absent during a given time interval is indicated by *.

Trethewey (1985) stated that "the greater the area of the intertidal zone and the adjacent subtidal zone out to at least 15m, the potentially better the habitat for waterfowl." Progressing from Trethewey's statement, we tested for a relationship between the surface areas of the intertidal zone and the number of birds the area supported. Table 12 shows the apparent preferred foraging locations of 29 species of birds. The total number of intertidal feeders observed within each sector was regressed against the surface area of the intertidal zone in each sector. The same method was applied to the relationships between shallow water, mid-depth and deep water feeders and the surface area of the appropriate habitats. Table 13 shows the results of the regression analyses. With the exception of those species that foraged primarily in mid-depth water, there were highly significant correlations between the surface areas of the preferred habitat type, and the total number of birds present.

Roost Sites in Saanich Inlet

Manuwal et al. (1979) stated that roost sites were an important aspect of the life histories of marine birds. These authors identified a variety of roosts including: the surface of the water, isolated rocks, islands, spits, beaches, log booms, buoys, docks, boats, pilings and buildings. We investigated the importance of manmade structures as roost sites and found that only 11 species used these surfaces. Table 14 lists the average percentage roosting on artificial surfaces, out of the total inlet population. Several species rarely used manmade roosts. However, to species such as Common Tern, Pelagic Cormorant, Double-crested Cormorant and Glaucous-winged Gull ,the importance of manmade structures is obvious. The locations that consistently supported the highest number of birds roosting on artificial surfaces were Mill Bay, Patricia Bay, Deep Cove and Brentwood Bay. The presence of numerous roosts likely accounts in part for the rich avifauna observed in the shallow bays of Saanich Inlet.

Table 12. Water habitat types where each species most frequently foraged (in Patricia Bay).

Intertidal	Shallow Water <2m	Mid-depth 2-5m	Deep Water >5m
Mallard	Common Loon	Pelagic Cormorant	Pacific Loon
Northern Pintail	Red-necked Grebe	Bonaparte's Gull	Western Grebe
Blue-winged Teal	Horned Grebe		Common Murre
Mew Gull	Eared Grebe		Pigeon Guillemot
California Gull	Double-crested Cormorant		
Glaucous-winged Gull	Great Blue Heron		
	American Wigeon		
	Greater Scaup		
	White-winged Scoter		
	Surf Scoter		
	Oldsquaw		
	Barrow's Goldeneye		
	Common Goldeneye		
	Bufflehead		
	Red-breasted Merganser		
	Hooded Merganser		
	Marbled Murrelet		

Table 13. The approximate surface area (m^2) of the four feeding habitats within Patricia Bay and the population of birds in each. The number of birds was determined by summing the totals of the appropriate species listed in Table 12 (eg the number of beach feeding birds observed on beaches).

	Surface Area	Beach Feeders	Surface Area	Shallow Water Feeders	Surface Area	Mid-Depth Feeders	Surface Area	Deep Water Feeders
Sector								
1	14750	36	17900	103	16600	7	400	0
2	10600	23	9150	214	10000	0	6650	0
3	16800	50	17050	243	11850	7	33250	4
4							256450	16
5							354000	36
6	45500	116	15950	63	27400	33	235700	12
7	21200	57	22850	520	21800	28	120900	11
8	80200	100	45300	965	44000	15	65600	2
9	103800	363	65000	1117	30300	17	40900	6
10	28250	73	16400	252	14700	5	7300	1
11	33250	106	17000	432	11200	4	2500	0
12	47150	164	15000	706	14750	15	650	0
	$r = +.86542$ $p<.001$		$r = +.81851$ $p<.0025$		$r = +.55083$ ns		$r = +.93792$ $p<.0005$	

note: Sectors 4 and 5 had negligible amounts of beach, shallow and mid-depth water habitats.

Table 14. Bird species that were observed roosting on manmade structures, and the average proportion of the total number present in Saanich Inlet (entire study period).

Species	Total Number of Birds	% Roosting
Common Tern	186	64.6
Double-crested Cormorant	1331	60.2
Pelagic Cormorant	1220	56.6
Glaucous-winged Gull	10491	33.4
California Gull	604	25.6
Common Merganser	466	17.9
Mew Gull	2038	16.8
Great Blue Heron	314	10.3
Bonaparte's Gull	1002	9.2
Mallard	344	1.0
Hooded Merganser	378	0.3

SUMMARY

The results of this study showed that in Saanich Inlet the greatest number of marine birds and the highest number of species occurred during the winter. During December, we found a total of nearly 7400 birds made up of 37 species. In contrast, during June there were as few as 500 birds (14 species) in all of Saanich Inlet. These changes dramatically illustrated the influence the fall migration period had on the breeding season population.

Shallow bays consistently supported the largest and richest avifauna, followed by those areas with extensive beaches and intertidal zones. Waters off rocky shores and open-water reaches supported the fewest species and the lowest number of birds.

With increasing tide heights, bays supported significantly fewer birds, whereas there were proportionately more birds in open-water habitats.

Species of birds that feed in the exposed intertidal zone and in the shallows at the edge of the beach fed significantly less with increasing tide height.

We observed a strong positive correlation between the number of birds that prefer to forage within a given habitat type and the surface area of their preferred habitat.

Deep water habitats along steep rock walls did not support the highest densities of Surf Scoters. Instead, they reached their peak abundance in shallow bays.

RECOMMENDATIONS FOR FURTHER STUDIES

1) The effects of tide level and time of day on the foraging behaviour of marine birds needs to be investigated.
2) The possible association between the number of birds that forage in a particular habitat type and the extent of that habitat should be examined.
3) Detailed studies of the preferred prey and foraging habitats (and how these change seasonally) should be undertaken for at least the most common species of marine birds.
4) The role that manmade roosts play in determining the composition, distribution and abundance of marine birds needs further study.

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APPENDIX 1. List of all species of birds encountered in this study. Latin names, code names and guild affiliations are also presented.

Bird Species		Code	Guild
Common Loon	Gavia immer	COLO	Loon
Yellow-billed Loon	G. adamsii	YBLO	Loon
Pacific Loon	G. pacifica	PALO	Loon
Red-throated Loon	G. stellata	RTLO	Loon
Western Grebe	Aechmophorus occidentalis	WEGR	Grebe
Red-necked Grebe	Podiceps grisegena	RNGR	Grebe
Horned Grebe	P. auritus	HOGR	Grebe
Eared Grebe	P. nigricollis	EAGR	Grebe
Pied-billed Grebe	Podilymbus podiceps	PBGR	Grebe
Leach's Storm-petrel	Oceanodroma leucorhoa	LESP	Pelagic Seabird
Double-crested Cormorant	Phalacrocorax auritus	DCCO	Cormorant
Brandt's Cormorant	P. penicillatus	BRCO	Cormorant
Pelagic Cormorant	P. pelagicus	PECO	Cormorant
Great Blue Heron	Ardea herodias	GBHE	Heron
Mute Swan	Cygnus olor	MUSW	Swan/Geese
Canada Goose	Branta canadensis	CAGO	Swan/Geese
Brant	B. bernicla	BRAN	Swan/Geese
Mallard	Anas platyrhynchos	MADU	Dabbling Duck
Green-winged Teal	A. crecca	GWTE	Dabbling Duck
American Wigeon	A. americana	AMWI	Dabbling Duck
Eurasian Wigeon	A. penelope	EUWI	Dabbling Duck
Northern Pintail	A. acuta	NOPI	Dabbling Duck
Blue-winged Teal	A. discors	BWTE	Dabbling Duck
Greater Scaup	Aythya marila	GRSC	Bay Duck
Lesser Scaup	A. affinis	LESC	Bay Duck
Black Scoter	Melanitta nigra	BLSC	Sea Duck
White-winged Scoter	M. fusca	WWSC	Sea Duck
Surf Scoter	M. perspicillata	SUSC	Sea Duck
Harlequin Duck	Histrionicus histrionicus	HADU	Sea Duck
Oldsquaw	Clangula hyemalis	OLDS	Sea Duck
Barrow's Goldeneye	Bucephala islandica	BAGO	Bay Duck
Common Goldeneye	B. clangula	COGO	Bay Duck
Bufflehead	B. albeola	BUFF	Bay Duck
Common Merganser	Mergus merganser	COME	Merganser
Red-breasted Merganser	M. serrator	RBME	Merganser
Hooded Merganser	Lophodytes cucullatus	HOME	Merganser
American Coot	Fulica americana	AMCO	Coot
Bonaparte's Gull	Larus philadelphia	BOGU	Gull/Tern
Mew Gull	L. canus	MEGU	Gull/Tern
Herring Gull	L. argentatus	HEGU	Gull/Tern
California Gull	L. californicus	CAGU	Gull/Tern
Thayer's Gull	L. thayeri	THGU	Gull/Tern
Western Gull	L. occidentalis	WEGU	Gull/Tern

Appendix 1 continued.

Bird Species		Code	Guild
Glaucous-winged Gull	L. glaucescens	GWGU	Gull/Tern
Common Tern	Sterna hirundo	COTE	Gull/Tern
Common Murre	Uria aalgae	COMU	Alcid
Pigeon Guillemot	Cepphus columba	PIGU	Alcid
Marbled Murrelet	Brachyramphus marmoratus	MAMU	Alcid
Ancient Murrelet	Synthliboramphus antiquus	ANMU	Alcid
Rhinoceros Auklet	Cerorhinca monocerata	RHAU	Alcid

APPENDIX 2. Densities (birds/km) of all species observed in Saanich Inlet, averaged over entire study period. Where each species reached its maximum density is indicated by a *. See Appendix 1 for species codes.

Species	Transect Number 1	2	3	4	5	6	7	8	9	10	11	12	13
COLO	2.5	12.7	19.4	6.6	5.3	1.2	14.5	16.1	29.4*	5.1	12.8	4.4	8.2
YBLO	0.0	0.0	0.0	0.0	0.0	0.0	0.4*	0.0	0.3	0.0	0.0	0.0	0.0
PALO	6.9	0.4	0.9	3.1	2.5	3.5	27.2	2.4	4.9	45.5	0.5	7.3	0.7
RTLO	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4
WEGR	1699.0*	5.9	912.9	0.9	4.1	35.0	35.1	1.2	1.1	0.3	1.5	0.3	0.0
RNGR	4.3	9.8	18.1	11.4	13.1	0.9	23.6	20.2	63.2*	21.1	16.3	11.1	18.3
HOGR	3.2	67.4	84.5	21.9	25.8	4.7	72.8	134.7	265.4*	71.7	81.6	19.6	30.9
EAGR	0.0	1.7	3.0	0.0	0.0	0.0	2.5	4.4	12.6*	0.6	1.5	0.6	2.6
PBGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1*	0.0	0.0	0.0	0.8
LESP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4*
DCCO	3.2	14.8	33.6	3.9	11.5	4.7	30.1	20.6	56.3*	16.3	11.2	5.4	8.2
PECO	0.5	19.1	18.1	7.9	4.5	10.3	40.9	63.3*	45.6	45.2	16.8	15.8	20.2
BRCO	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0
GBHE	0.0	4.7	17.2	4.4	2.1	0.3	4.7	5.7	5.2	1.8	1.5	0.9	3.4
MUSW	0.0	0.0	2.6	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAGO	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.8
BRAN	1.3*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MADU	0.0	0.9	15 5	2.6	3.3	0.0	0.4	11.3	24.7*	5.4	0.0	0.0	0.8
GWTE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6*	0.0	0.0	0.0	0.0
AMWI	0.0	39.4	87.5*	10.9	86.9	0.0	3.9	9.7	63.5	31.3	10.2	2.2	0.8
EUWI	0.0	0.0	0.0	0.4*	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRSC	0.0	0.0	11.2	0.0	0.0	1.5	1.8	4.4	53.3*	0.0	5.6	0.0	0.0
LESC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2*	0.0	0.0	0.0	0.0
BLSC	0.0	0.0	2.2	0.0	0.0	0.0	1.8	1.2	12.6*	0.3	0.0	0.0	0.8
WWSC	5.0	13.6	17.7	2.2	4.5	0.9	31.9	115.7	522.8*	12.0	77.0	1.9	0.4
SUSC	3.4	23.3	219 4	18.9	16.4	2.9	23.6	101.2	283.5*	17.5	103.6	6.9	8.6
HADU	0.0	0.0	2.6	3.5	1.2	0.0	3.3	16.9*	4.9	8.7	0.0	0.0	0.0
OLDS	0.0	2.1	2.2	0.9	0.0	2.9	1.4	1.2	9.1	10.6*	0.0	0.9	3.3
BAGO	0.0	97.5*	96.9	72.8	47.5	0.0	55.8	35.1	74.2	80.1	32.6	54.1	21.6
COGO	0.2	40.3	111.6	25.0	34.4	0.3	33.3	80.2	155.2*	43.1	29.6	16.8	36.9
BUFF	0.0	56.4	273.3	17.1	42.6	0.0	57.9	114.1	316.2*	46.9	151.5	14.9	27.9
COME	0.4	5.1	3.0	0.0	2.9	0.0	0.0	1.6	4.4	0.3	1.0	3.5	4.1
RBME	6.3	88.9	96.9	44.3	114.3	2.7	112.7	93.5	253.6*	79.5	62.2	43.4	35.4
HOME	0.0	6.4	6.5	4.4	2.5	0.0	26.8*	23.8	15.7	8.7	4.1	3.5	5.6
AMCO	0.0	0.0	3.5*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOGU	1.6	9.7	15.5	7.0	15.9	10.6	30.1	14.9	19.8	3.3	0.5	4.8	8.9
MEGU	3.8	35.2	106.5*	10.5	18.5	2.9	8.3	46.4	105 8	14.2	6.6	4.1	4.5
HEGU	0.2	0.0	1.3*	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
CAGU	0.5	4.2	9.5	26.8	70.5*	3.8	1.1	6.9	18.7	0.9	2.0	0.6	0.8
THGU	0.0	0.4	3.0*	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WEGU	0.0	0.4	0.9*	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.0	0.0	0.0

Appendix 2 continued.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13
GWGU	26.3	144.4	196.1	70.6	118.8	23.5	137.3	104.8	189.8	106.6	95.4	47.8	113.4
COTE	0.0	0.9	0.9	0.9	0.4	0.0	26.5*	9.3	5.2	0.0	0.0	0.0	0.0
COMU	24.6*	1.3	0.9	1.8	1.2	10.6	1.8	0.4	0.6	3.9	0.0	6.3	0.0
PIGU	0.0	3.8	1.3	1.3	2.1	1.5	4.7	4.4	4.1	5.7*	5.1	1.9	4.9
MAMU	1.1	5.5	6.0	6.6	3.7	6.2	6.5	2.8	0.3	4.2	1.5	4.4	3.4
ANMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3*	0.0	0.0	0.0
RHAU	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4

Appendix 2 continued.

Species	14	15	16	17	18	19	20	21	22	23	24	25	26
COLO	2.0	2.2	0.6	0.0	0.0	0.6	0.8	0.8	1.4	0.4	6.3	12.5	3.1
YBLO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PALO	0.0	0.0	0.0	0.0	0.8	0.4	1.4	0.7	0.0	1.1	4.2	3.8	68.8*
RTLO	0.5*	0.0	0.0	0.0	0.4	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0
WEGR	0.0	0.0	0.0	0.3	1.9	0.0	2.5	0.0	0.0	3.5	2.8	3.8	351.5
RNGR	17.3	4.9	5.8	3.4	1.5	4.3	3.5	3.0	1.8	0.7	10.6	20.6	2.8
HOGR	27.1	21.2	4.1	1.4	2.3	3.1	0.8	1.7	3.9	0.0	14.8	55.6	1.2
EAGR	1.0	2.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
PBGR	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
LESP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DCCO	31.6	5.9	0.0	3.4	0.0	13.8	13.3	3.7	3.9	0.4	4.9	22.5	3.4
PECO	37.2	3.3	1.7	9.1	2.3	4.5	4.6	4.4	1.8	3.2	3.9	8.1	1.2
BRCO	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.6	0.0
GBHE	5,9	34.2*	0.0	1.4	1.9	3.5	2.1	0.7	2.2	0.0	3.2	2.5	0.0
MUSW	0.0	0.0	0.0	0.0	0.0	4.5*	2.2	0.2	0.0	0.0	0.7	1.3	0.0
CAGO	1.0	25.0*	0.0	0.0	0.0	5.7	0.6	1.3	0.0	0.0	1.4	0.0	0.0
BRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MADU	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	1.1	1.3	0.0
GWTE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AMWI	0.0	5.4	0.0	0.0	0.0	1.4	0.0	0.0	4.3	0.0	20.8	39.4	1.9
EUWI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
LESC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BLSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
RWSC	2.6	0.0	0.0	0.0	0.0	4.5	0.3	0.0	17.5	0.0	19.4	29.4	0.3
SUSC	0.5	0.0	0.0	0.0	0.0	2.4	0.0	0.0	7.5	0.0	53.2	43.8	0.0
HADU	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OLDS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAGO	38.8	43.4	4.7	19.6	16.7	11.6	38.1	26.5	25.4	0.0	41.9	37.5	0.0
COGO	20.4	22.3	1.7	16.2	6.4	18.7	3.5	2.8	7.9	0.0	17.9	25.0	0.0
BUFF	12.2	65.8	5.7	3.0	2.3	132.3	6.8	0.4	6.8	0.0	24.3	85.0	0.0
COME	5.6	32.1*	6.6	5.7	7.6	31.3	7.4	10.9	4.9	1.1	4.2	0.0	0.0
RBME	18.4	65.2	19.8	13.5	10.9	11.8	2.7	15.9	9.9	1.8	31.3	36.9	0.6
HOME	3.1	6.5	4.1	0.0	0.8	1.4	0.9	0.0	1.1	0.0	0.0	3.1	0.0
AMCO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOGU	0.5	5.9	0.0	1.0	5.3	31.9	10.9	8.5	7.1	8.8	22.9	47.5*	4.0
MEGU	5.6	3.8	2.3	6.4	7.9	25.4	30.2	17.4	21.4	21.1	34.5	23.8	4.0
HEGU	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.1	0.0	0.0
CAGU	1.0	1.6	0.0	0.0	0.0	0.2	4.1	3.7	0.0	3.2	43.7	15.6	0.3
THGU	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
WEGU	0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
GWGU	703.1*	447.9	47.7	63.5	29.2	190.0	83.5	25.9	238.6	21.5	185.9	138.8	14.8
COTE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.8	0.6	0.6
COMU	0.0	0.0	0.6	1.4	1.5	2.2	3.3	2.6	8.9	13.0	1.1	4.4	6.8
PIGU	0.0	0.0	0.0	0.7	0.0	0.0	0.2	0.0	0.4	0.0	0.0	1.3	0.3
MAMU	3.1	0.0	1.2	0.7	0.0	0.9	0.2	1.1	1.4	0.7	1.8	10.1*	0.6
ANMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RHAU	0.5	0.0	0.0	0.7	0.0	0.2	3.2*	1.1	0.4	0.0	0.0	0.0	0.3

APPENDIX 3. Species identified from the intertidal and subtidal sampling of Patricia Bay. Presence(+) or absence(-) is indicated for the four major zones (U = upper intertidal, M = middle intertidal, L = lower intertidal, S = subtidal). Identifications that have not been verified are indicated by *.

	Area I				Area II				Area III			
	U	M	L	S	U	M	L	S	U	M	L	S
Marine Flora												
Chlorophyceae												
Cladophora columbiana	-	+	-	-	-	-	-	-	-	-	-	-
C. sp.	-	-	+	-	-	-	-	-	-	-	-	-
Enteromorpha linza	+	+	+	-	-	+	+	-	-	-	+	-
Ulva sp.	-	+	+	+	-	+	+	+	-	-	+	+
Rhodophyceae												
Corallina vancouveriensis*	-	+	-	-	-	-	-	-	-	-	-	-
Gigartina cristata	+	+	-	-	-	+	-	-	+	+	-	-
Gracilariopsis sjoestedtii	-	+	-	-	-	+	+	-	-	-	-	-
Odanthallia floccosa*	+	+	+	-	-	-	-	-	-	+	-	-
Petrocelis sp.	-	+	-	-	-	-	-	-	-	+	+	-
Polysiphona sp.	-	-	-	-	-	+	+	-	-	-	-	-
Rhodoglossum affine	-	-	+	-	-	-	-	-	-	-	-	-
Rhodomela larix	-	-	+	-	-	-	-	-	-	-	-	-
Phaeophyceae												
Fucus distichus	+	+	+	-	-	-	-	+	+	+	+	-
Leathesia diformis	-	+	-	-	-	-	-	-	-	-	+	-
Ralfsia sp.	+	+	-	-	-	-	-	-	-	+	-	-
Sargassum muticum	-	+	+	-	-	-	+	-	-	-	+	+
Scytosiphon lomentaria	-	-	-	-	-	-	-	-	-	-	+	-
Flowering Plants												
Zostera marina	-	+	+	+	-	+	+	+	-	-	+	+
Marine Fauna												
Coelenterata												
Anthopleura elegantissima	-	-	+	-	-	-	+	-	-	-	-	-
A. xanthogrammica	-	+	+	-	-	-	-	-	-	-	-	-
Pachycerianthus fimbriatus	-	-	-	-	-	-	-	-	-	-	-	+
Ptilosarcus gurneyi	-	-	-	+	-	-	-	-	-	-	-	-
Platyhelminthes												
Polycladida	-	-	-	+	-	+	-	-	-	+	-	-
Nemertea												
Cerebratulus sp.	-	-	+	+	-	-	+	-	-	-	-	-

Appendix 3 continued.

Tubulanus polymorphus	-	-	+	-	-	-	-	-	-	-	+	-
Lineus ruber*	-	-	+	+	-	-	-	-	-	-	-	-
Paranemertes peregrina	-	-	-	-	-	-	-	-	-	-	-	+
Nematoda												
Adenophorea*	-	-	+	+	-	-	-	+	-	-	-	+
Annelida												
Leitoscoloplos elongatus	-	-	-	-	-	-	+	-	-	-	-	-
Paraonella platybranchia*	-	-	-	+	-	-	-	-	-	-	-	-
Prionospio steestrupi	-	-	-	-	-	-	-	+	-	-	-	-
P. sp.	-	-	-	+	-	-	-	-	-	-	-	+
Magelona hobsonae	-	-	-	-	-	-	-	-	-	-	-	+
Mesochaetopterus taylori	-	-	-	-	-	-	+	-	-	-	-	-
Notomastus lineatus	-	-	-	+	-	-	-	-	-	-	-	-
N. tenuis	-	+	+	-	-	+	+	-	-	-	+	-
Axiothella rubrocincta	-	-	-	-	-	+	+	-	-	-	-	-
Armandia brevis*	-	-	-	-	-	-	-	-	-	-	-	+
Halosydna brevisetosa	-	-	+	-	-	-	-	-	-	-	-	-
Harmothoe imbricata	-	+	-	+	-	-	-	-	-	-	-	-
Pholoe caeca	-	-	-	-	-	-	-	+	-	-	-	-
Ophiodromus pugettensis	-	-	-	-	-	-	-	+	-	-	-	-
Syllis sp.	-	-	-	+	-	-	-	-	-	-	-	-
Nereis procera	-	-	-	+	-	-	-	-	-	-	-	-
N. vexillosa	-	-	-	-	-	-	-	-	+	+	-	-
Platynereis bicanaliculata	-	+	-	+	-	-	-	+	-	+	-	+
Glycera americana	-	+	-	-	-	-	+	-	+	-	-	-
Nephtys californiensis	-	-	+	-	-	-	+	-	-	-	-	-
N. cornuta franciscana	-	-	-	+	-	-	-	+	-	-	-	-
Dorvillea pseudorubrovittata	-	-	-	-	-	-	-	+	-	-	-	-
D. rudolphi	-	-	-	+	-	-	-	-	-	-	-	-
Owenia fusiformis	-	-	-	-	-	-	-	+	-	-	-	-
Amage anops	-	-	-	-	-	-	-	+	-	-	-	-
Amphicteis mucronata	-	-	-	+	-	-	-	+	-	-	-	-
Neoamphitrite robusta	-	-	+	-	-	-	-	-	-	-	+	-
Eudistylia sp.	-	-	-	+	-	-	-	-	-	-	-	-
Serpula vermicularis	-	+	+	-	-	-	-	+	-	-	+	-
Tubificid oligochaete	-	-	-	+	-	-	-	-	-	-	-	-
Crustacea												
Longipedia americana	-	-	-	+	-	-	-	-	-	-	-	-
Ectinosomatidae	-	-	+	-	-	-	-	-	-	-	-	-
Harpacticus sp.	-	-	+	-	-	-	-	+	-	-	-	+
Dactylopodia vulgaris	-	-	-	+	-	-	-	-	-	-	-	-
D. sp.	-	-	-	+	-	-	-	+	-	-	-	+
Amphiascus minutus	-	-	-	-	-	-	-	+	-	-	-	-
Robertgurneya sp.	-	-	-	-	-	-	-	+	-	-	-	-
Typhlamphiascus sp.	-	-	-	+	-	-	-	+	-	-	-	+
Heterolaophonte variabilis	-	-	+	-	-	-	-	-	-	-	-	-
Chthamalus dalli	+	-	-	-	+	-	-	-	+	+	-	-
Balanus glandula	+	-	-	-	+	+	-	-	+	+	-	-

Appendix 3 continued.

B. cariosus	+	+	-	-	+	+	-	-	-	+	-	-
B. nubilus	-	+	+	-	-	+	-	-	-	-	+	-
B. sp.	-	-	+	+	-	-	+	+	-	-	+	+
Cumella vulgaris*	-	-	+	-	-	-	+	-	-	-	+	-
Leptochelia dubia*	-	-	-	-	+	-	-	+	-	-	-	+
Gnorimosphaeroma oregonensis	-	+	-	-	-	-	-	-	-	+	-	-
Idotea resecata	-	-	-	-	-	-	+	+	-	-	-	-
I. wosnesenskii	+	+	-	-	-	-	-	-	-	-	-	-
Munna ubiquita*	-	-	-	+	-	-	-	+	-	-	-	-
Ampithoe simulans	-	+	-	-	-	+	-	-	-	+	-	-
A. valida	-	-	-	-	-	-	+	-	+	+	-	-
A. sp.	-	-	+	-	-	-	-	-	-	-	-	-
Allorchestes angusta	+	-	-	-	-	-	-	-	-	-	-	-
Aoroides intermedius	-	-	-	+	-	-	-	+	-	-	-	-
A. sp.	-	-	-	-	-	-	-	+	-	-	-	+
Corophium sp.	-	-	-	+	-	-	-	+	-	-	-	-
Guernea reduncans	-	-	-	+	-	-	-	-	-	-	-	-
Hyale plumosa	+	-	-	-	+	-	-	-	-	-	-	-
Photis brevipes	-	-	-	+	-	-	+	-	-	-	-	+
P. sp.	-	-	-	+	-	-	-	-	-	-	-	-
Foxiphalus obtusidens	-	-	-	+	-	-	-	-	-	-	-	-
Synchelidium shoemakeri	-	-	-	-	-	-	-	-	-	-	-	+
Hippolyte clarki	-	-	-	+	-	-	-	-	-	-	-	-
Heptacarpus brevirostrus	-	-	-	+	-	-	-	-	-	-	-	-
H. littoralis	-	-	-	+	-	-	-	-	-	-	-	-
H. paludicola	-	-	-	+	-	-	-	+	-	-	-	+
H. sitchensis	-	-	-	+	-	-	-	-	-	-	-	-
Crangon franciscorum franciscorum	-	-	-	+	-	-	-	+	-	-	-	-
Pagurus sp.	+	+	+	+	-	+	+	-	+	+	+	+
Petrolisthes eriomerus	-	-	+	-	-	-	-	-	-	-	-	-
Pugettia gracilis	-	-	+	-	-	-	+	-	-	-	-	-
P. producta	-	+	+	-	-	-	+	+	-	-	+	+
Telmessus cheiragonus	-	-	-	+	-	-	-	-	-	-	-	-
Cancer gracilis	-	-	-	-	-	-	-	+	-	-	+	+
C. magister	-	-	-	-	-	-	+	-	-	-	-	-
C. productus	-	+	+	+	-	-	+	+	-	-	+	+
Lophopanopeus leucomanus	-	-	+	-	-	-	-	-	-	-	-	-
Hemigrapsus sp.	+	+	+	+	+	+	-	+	+	+	+	-
Insecta												
Cricotopus/Orthocladius sp.	-	-	+	-	-	-	-	-	-	-	-	-
Mollusca												
Lepidozona mertensii	-	-	+	-	-	-	-	-	-	-	-	-
Mopalia ciliata	-	-	+	+	-	-	-	-	-	-	+	-
M. lignosa	-	-	+	-	-	-	-	-	-	-	-	-
Collisella pelta	-	+	-	-	-	+	-	-	-	+	+	-
C. digitalis	+	+	-	-	-	-	-	-	+	-	-	-
C. sp.	-	-	-	+	-	-	-	-	-	-	-	+
Notoacmea persona	-	-	-	-	+	+	+	-	+	+	+	-
N. scutum	+	+	-	-	+	+	-	-	-	-	-	-

Appendix 3 continued.

Callistoma sp.	-	+	+	+	-	-	+	+	-	-	+	+
Margarites salmoneus	-	-	+	-	-	-	+	-	-	-	+	-
Tegula sp.	-	-	-	-	-	-	-	+	-	-	-	-
Littorina scutulata	+	+	-	-	+	+	-	-	+	+	+	-
L. sitkana	+	+	-	-	-	+	-	-	-	+	-	-
Bittium eschrichtii	-	-	+	-	-	-	-	-	-	-	+	+
Crepidula adunca	-	+	-	-	-	-	-	-	-	-	-	-
Polinices lewisii	-	-	-	-	-	-	-	-	-	-	-	+
Nucella lamellosa	-	+	-	-	-	-	-	+	-	-	+	-
Nassarius sp.	-	-	-	-	-	-	-	+	-	-	-	-
Haminoea vesicula	-	-	+	-	-	+	+	-	-	-	-	-
Phyllaplysia taylori	-	-	-	-	-	-	+	+	-	-	-	-
Acanthodoris brunnea	-	-	-	-	-	+	-	-	-	-	+	-
Anisodoris nobilis	-	-	+	+	-	-	-	-	-	-	-	+
Archidoris montereyensis	-	-	+	-	-	-	-	+	-	-	-	+
A. odhneri*	-	-	+	-	-	-	-	-	-	-	-	-
Diaula sandiegensis	-	-	-	-	-	-	-	-	-	-	-	+
Hermissenda crassicornis	-	-	-	+	-	-	-	-	-	-	-	+
Melibe leonina	-	-	-	+	-	-	-	+	-	-	-	-
Onchidoris bilamellata	-	+	-	-	-	-	-	-	-	-	-	-
Pododesmus macrochisma	-	+	+	-	-	-	+	-	-	-	+	+
Diplodonta orbella	-	-	+	+	-	-	-	-	-	-	-	-
Modiolus rectus	-	-	-	-	-	-	+	-	-	-	-	-
Mytilus edulis	+	+	-	-	-	+	+	-	+	+	+	-
Crassostrea gigas	-	-	-	-	-	+	+	-	+	+	+	-
Kellia laperousii*	-	-	+	-	-	-	-	-	-	-	-	-
Clinocardium nuttallii	-	-	+	-	-	-	+	+	-	-	-	-
Protothaca staminea	-	-	+	-	-	+	+	-	-	+	+	-
Saxidomus giganteus	-	-	+	-	-	-	+	-	-	-	+	+
Transennella tantilla*	-	-	+	-	-	-	-	-	-	-	-	-
Schizothaerus capax	-	-	+	-	-	-	+	+	-	-	-	+
Semele sp.	-	-	-	-	-	-	+	-	-	-	-	-
Tellina sp.*	-	-	+	-	-	-	-	-	-	-	-	-
Macoma nasuta	-	+	+	+	-	+	+	-	-	-	-	-
Echinodermata												
Crossaster papposus	-	-	+	-	-	-	-	-	-	-	-	+
Solaster stimpsoni	-	-	-	-	-	-	-	+	-	-	-	+
Henricia leviuscula	-	-	+	-	-	-	-	-	-	-	-	+
Evasterias troschelii	-	+	+	+	-	+	-	+	-	-	+	+
Pisaster ochraceus	-	+	+	+	-	-	-	-	-	-	+	+
Dendraster excentricus	-	-	-	-	-	-	+	+	-	-	-	-
Ophiopholis sp.*	-	-	-	+	-	-	-	-	-	-	-	-
Cucumaria miniata	-	-	+	+	-	-	-	-	-	-	-	-
Eupentacta quinquesemita	-	-	+	+	-	-	-	-	-	-	-	-
Parastichopus californicus	-	-	+	+	-	-	-	-	-	-	-	+
Ascidia callosa	-	-	+	-	-	-	-	-	-	-	-	-
Cnemidocarpa finmarkiensis	-	-	+	-	-	-	-	-	-	-	-	-
Chordata												
Hippoglossoides elassodon	-	-	+	+	-	-	+	+	-	-	-	+

Appendix 3 continued.

Clinocottus acuticeps	-	-	-	-	-	-	+	-	-	-	-
Oligocottus maculosus	-	+	-	-	-	+	+	+	-	-	+	+
Gobiesox meandricus	-	-	+	-	-	-	-	-	-	-	-
Anoplarchus insignis	-	+	-	-	-	-	-	+	-	-	-	+
Ammodytes hexapterus	-	-	-	+	-	-	-	-	-	-	-

Number of Species/Zone:

Area I	Area II	Area III
U = 18	U = 9	U = 14
M = 44	M = 28	M = 23
L = 66	L = 43	L = 37
S = 57	S = 47	S = 43

Total number of Species/Area:

Area I = 130 Area II = 90 Area III = 79

Brief Descriptions Of Areas I, II & III.

Area I

This area extends south-west of the I.O.S. dock for approximately 1000m. As with areas II and III, there is almost no exposed beach at high tide. The substrate of this area (from supraintertidal to subtidal) is a mixture of pebble (0.4 - 6.4cm) and cobble (6.5 - 25.5cm) grading to cobble and boulder (>25.5cm) with large obtrusions of bedrock. The slope in this upper zone ranges between 5 and 8°. Lower down, the slope decreases to approximately 2° and the substrate is mostly bedrock with numerous tide pools and scattered patches of sand. Below the intertidal zone, the substrate rapidly changes to continuous sand with very few boulders.

Area II

Area II extends north of the I.O.S. dock for nearly 1600m. There is a narrow (<10m) beach of cobble and pebbles grading to cobble with scattered boulders. The average slope here is 5°. Less than 20m from the upper limit of the beach, the substrate becomes almost entirely muddy sand with very few scattered boulders. The slope decreases here to between 1 and 3°.

Area III

Area II intergrades into Area III. This section continues westward for almost 1100m until Warrior Point. The upper intertidal is mostly bedrock overlain with pockets of pebbles and small cobble. The upper slope averages 5°. Lower down, the substrate rapidly changes to sand with scattered rock islets. The average slope here is 3°.